POWER PLANT ENGINEERING

Trade-mark reg. U. S. Pat. Office

VOL. XXV CHICAGO, SEPTEMBER 15, 1921 No. 18

Meeting Power Needs of Growing Factory

DETAILS OF SERVICES REQUIRED AND TRANSFORMER SUBSTATION EQUIPMENT AND CONSTRUCTION. BY FRANK C. VOGAN

FEW consumer lines of our large serving companies connect in loads of an industrial nature greater than those associated with the manufacture of automobiles and their parts. In the northern part of Philadelphia is a big plant prominently connected with the motor car industry through the production of automobile bodies and the making and fabrication of difficult sheet metal shapes. The plant is situated about 5 mi. out from the center of the city, bordering the lines of the Pennsylvania and Philadelphia & Reading Railroads.

From the inception of the plant, it rapidly grew until it now occupies many acres. Dating from the beginning of operations, service for light and power has been furnished by the local lighting company. Throughout the many buildings, constituting the works, the positions of the earlier light and power centers bear strong evidence of how persistently all allowances made for future development have been exceeded. Provisions made for

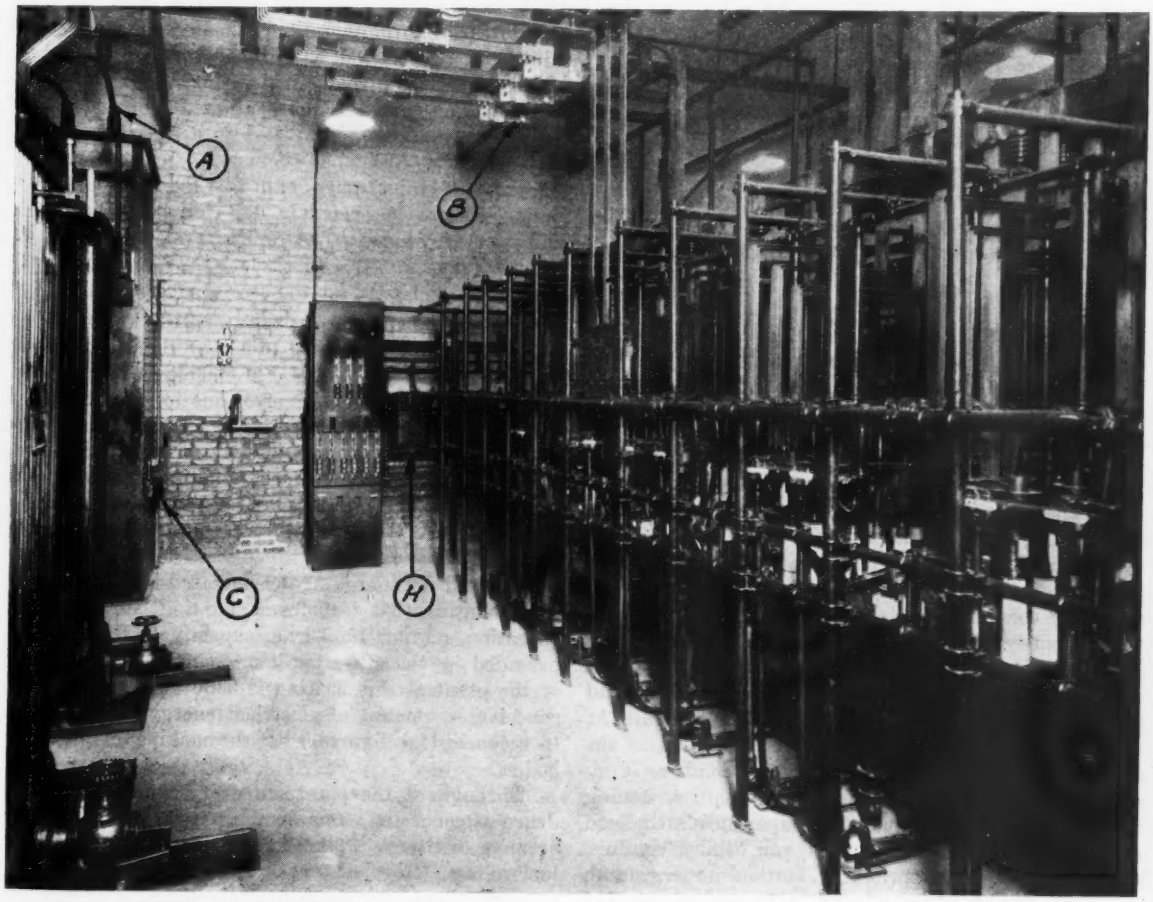


FIG. 2. INTERIOR OF STATION NO. 3

expansion, some 5 yr. ago, have been overwhelmed, and without additions, would be entirely inadequate to meet the present-day demands of the plant.

The local lighting company supplies the project with 13,200-v., 60-cycle, three-phase current. The high voltage current is transformed through the media of one main transformer station and two smaller ones, to low voltage for use throughout the plant. The current for power is three-phase, 220-v., and is delivered to the various receivers over a three-wire system. Lighting current is obtained from balance coils. These coils are grouped about the plant following the same general locations as the transformer stations. Current is supplied to the coils three-phase, three-wire at 220 v., but is taken off on the load side as single-phase current. From the secondaries of the coils the lighting current is used through a three-wire system at 220/110 v.

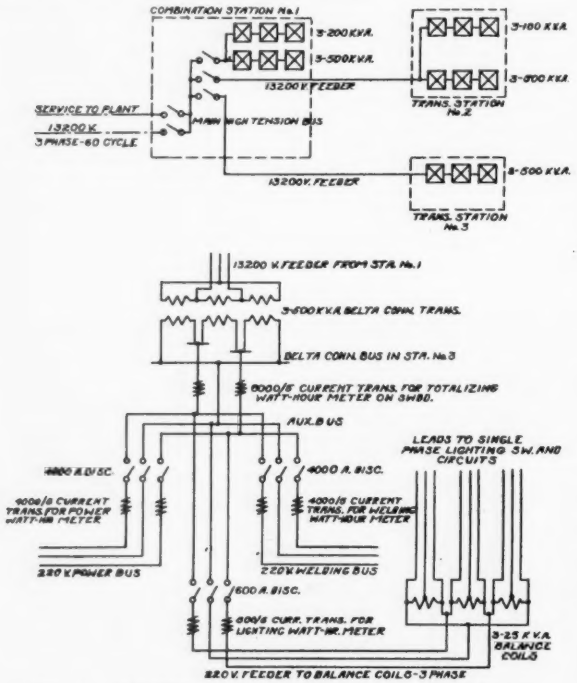

COMBINATION STATION No. 1
3-200 K.V.A.
3-500 K.V.A.
13200 V. FEEDER
3-100 K.V.A.
3-500 K.V.A.
TRANS. STATION No. 2
SERVICE TO PLANT
13200 V. 3 PHASE-60 CYCLE
MAIN HIGH TENSION BUS
13200 V. FEEDER
3-500 K.V.A.
TRANS. STATION No. 3
13200 V. FEEDER FROM STA. No. 1
3-500 K.V.A. DELTA CONN. TRANS.
DELTA CONN. BUS IN STA. No. 3
1000/5 CURRENT TRANS. FOR TOTALIZING WATT-HOUR METER ON SWBD.
AUX. BUS
LEADS TO SINGLE PHASE LIGHTING SW. AND CIRCUITS
4000 A. BUS
4000 A. BUS
1000/5 CURRENT TRANS. FOR POWER WATT-HR METER
4000/5 CURRENT TRANS. FOR WELDING WATT-HOUR METER
220 V. POWER BUS
220 V. WELDING BUS
600 A. BUS
600/5 CURR. TRANS. FOR LIGHTING WATT-HR. METER
3-25 K.V.A. BALANCE COILS
220 V. FEEDER TO BALANCE COILS-3 PHASE

FIG. 1. ELECTRICAL CONNECTIONS IN TRANSFORMER STATIONS

By this method of distribution, the economies of 220-v. circuits are obtained and the use of efficient 110-v. lamps is made possible. The plant is operated on a 24-hr. schedule, and, therefore, must be furnished with reliable and dependable service for the entire period. Through a rather elaborate system of high-voltage service feeders, the serving company has taken every precaution to insure continuity of service. The matter of supplying energy to this plant is a problem in itself. The main incoming service to the plant is carried in underground ducts under the highway until the site is reached. At a convenient point, a large manhole is provided in the sidewalk on the highway adjacent to the premises. Connections between the manhole and the main switching station in the plant are made in paper insulated, lead sheathed cables, which are, in turn, run in fiber conduit. These ducts enter the switching station underground, and, as an added measure of protection, are surrounded with an envelope of concrete throughout their extent.

In the plant, the main high tension service cables terminate in a high tension bus. The main high tension bus, along with all necessary metering and switching equipment, is housed in a combination switching and transformer station. (See wiring diagram of general connections.) The service cables are connected into the main bus through disconnect switches and oil circuit breakers of the full automatic type. The switching equipment that connects in the service cables is properly arranged and designed to control all current supply to the premises. The main oil circuit breakers are sufficiently rugged to withstand rupturing the entire service under full load conditions. The main high tension bus already referred to, supplies and controls current to three groups of transformers. These groups of transformers will be referred to later as stations Nos. 1, 2 and 3. The transformer stations are not unnecessarily elaborate and are located among the factory buildings, as load has from time to time demanded.

Originally, there was only one transformer station, namely the one erected in combination with the high tension switch station. The total capacity of the first station was 2100 kv.a. It contained one bank of three 500-kv.a. units and was shortly expanded by the addition of three 200-kv.a. units. All of these transformers are single-phase type, having both primaries and secondaries connected in closed delta, a practice that has been adhered to for all of the stations.

Station No. 1 had been in operation for only a brief while, when it became apparent that it would not be able to care for the increasing demand for current. An additional station was early placed under construction and rapidly completed. This new station, as already mentioned, is fed with current at 13,200 v. from the main combination station and is designated as transformer station No. 2. It is provided with two banks of single-phase transformers and, like the main station, the units here are connected in delta on both the primary and secondary sides. The banks in this outfit consist of three 500-kv.a. units and three 100-kv.a. units, making a total of 1800 kv.a. for the second station.

With a transformer capacity of 2100 kv.a. in station No. 1 and with 1800 kv.a. added by the No. 2 development, it seemed that the total of 3900 kv.a. would provide ample current supply for some time to come. Then the war came along. The chaotic conditions that the great struggle imposed on most industries need not be dwelt upon, further than to mention that this plant, because of its unusual equipment, suffered unusual demands. All the spare capacity carefully built into the No. 2 station was soon consumed. To show what happened and how the demand for energy again increased is briefly summed up in stating that transformer station No. 3 is now in operation, adding 1500 kv.a. capacity to the 3900 kv.a. provided by the other two stations. The total capacity of the plant at this writing is 5400 kv.a., an almost inconceivable amount of electrical energy when one tries to reconcile the figures with the making of automobile bodies.

Throughout the plant, on every hand, there is evidence of concerted effort on the part of the engineers to arrange with each transformer station, an associated low voltage (220) center of distribution. The distance between these transformer stations and the associated distributing centers has, in each case, been kept a mini-

mum. The reason for this is obvious. The length of the low voltage, high current carrying conductors is shortened, the points of likely trouble are centralized and the control of all feeders is concentrated. There has been provided for each transformer station, in an adjacent room where possible, a completely equipped switchboard from which all of the low voltage feeders radiate.

As this plant grew, the problems of getting low voltage power to the newly constructed buildings became quite a serious affair. With the building of each transformer station, due allowance was made for the normal growth of such an industry, but expansion in this project came with leaps and bounds. This sort of growth cannot be anticipated and it resulted in the doom of wisely laid plans. The erection of new buildings kept steady pace with the rapid growth of the automotive business. It seemed that, regardless of how much spare capacity a transformer station was allowed, it always vanished, and the same applies to feeder copper.

For our automobile body plant the power climax came late in the year of 1919. It took shape in the addition of a large four-story concrete building to be used for a machine shop. The new structure was located on the most remote section of the property owned by the company. The renewal of peace time activities in the automobile business promised much and to take care of the anticipated increase it became immediately necessary to increase the plant's facilities of production. To understand better the magnitude of expansions experienced with this industry we will consider some of the features of the new building that were directly responsible for the erection of the third transformer station.

Features of the New Building

The latest of the factory buildings in this group is one of the cage type, constructed of reinforced concrete. Provision for natural light and ventilation has been well cared for by the architects. This is witnessed in the unstinted use of large rolled steel sash. These steel framed windows transform the outer walls of the building into practically unbroken areas of glass. The four-story building measures 325 by 100 ft. and furnishes a total floor area of about 110,000 sq. ft. The floors, of concrete, designed for a load of 200 lb. per sq. ft., are supported by round concrete columns spaced at intervals that divide the floor areas into bays 25 ft. square. The floor heights vary between 18 and 20 ft., clear. As a flat slab construction has been used, maximum ceiling heights obtain.

Interior walls and partitions are finished in matt white paint which in no small way accounts for the wonderfully cheerful aspect presented by the shops. For the artificial illumination of the building, high powered gas filled Mazda units are used. The class of work performed, namely, the machining and handling of both large and small dies, requires that lighting be given special attention. The lighting outlets are arranged two to the bay, being placed on the diagonal quarters of the 25-ft. squares. With the use of 300-w. lamps and uniform spacing, illumination is received at seven foot-candles on the working plane, which in this case is the floor. For the lighting of closely applied machine work, local lamps are used on the machines themselves. The 300-w. overhead lamp units are provided with enameled steel reflectors. The reflectors and the lamp units are placed as high above the floor as possible, the lamp sockets being directly attached to the outlet boxes. All branch wiring for the lighting system is done with No. 12 wire in ¾-in. conduit run concealed in the floor slab. To control the branch wiring circuits, two lighting panel boards are provided on each floor. For the local control of the 464 lighting outlets in the main working areas, 124 flush push button switches conveniently placed on the interior columns are provided. In sections where this method of controlling the lighting outlets is not desirable, 288 pull switches have been installed on the ceiling adjacent to the lamp outlets.

Attention need not be called to the fact that the design as affects the layout of main power circuits in a project of this sort is always subject to criticism. No definite space nor location really can be assigned to any one part of the process. As business develops, the various parts of the processes rapidly outgrow the space allotted to them. There is always a certain amount of shifting around of departments, with the result that any system of power distribution that is not flexible to some extent soon has to be abandoned or reinstalled. As a rule, there is only one division of the work that can be located with any degree of permanency, that being work so heavy as to demand the use of overhead traveling cranes. Usually this part of the work is confined to the lower floor, or the one nearest the outside grade. Due to this, the craneways in this building are found on the ground floor.

There are four craneways in this structure, each of which extends the entire length of the building. The crane equipment consists of three 5-ton and one 10-ton units, all of which are operated from three-phase, three-wire overhead trolley systems. The crane trolley conductors are located at one side of the respective ways and by means of insulators are attached to racks on the floor columns which at the same time afford support for the craneways. The crane motors are operated with 220-v. current. For each five-ton equipment there are one 4-hp. and two 12.5-hp. motors, while for the 10-ton unit there are one 4-hp., one 12.5-hp., and one 25-hp. motor. For supplying current to the entire crane equipment, one large junction box is located near the center of the building on the first floor. From this box, taps are made to the various crane trolleys. Between the box and transformer station No. 3 there is one three-wire feeder consisting of 500,000-cm. copper.

Beside furnishing current to the cranes and lighting mentioned, the new transformer station handles an elevator load of 36 hp., a miscellaneous load of 980 hp. and a welding load of 540 hp. A schedule of the connected load on transformer station No. 3 is given in the appended list, which is of interest.

Connected Power and Lighting Load, Transformer Station No. 3

Receiver Name	Connected HP.	Connected Kw.	Power Factor	Connected Kv.a.	Demand Factor	Transformer Load Kv.a.
Misc. Power	980	730	.80	915	.75	686
Elevator	36	27	.80	34	.75	26
Cranes	128	96	.80	120	.75	90
Welding	540	402	.30	1340	.60	802
Lighting		173	...	....	.80	137
Total						1741

One will observe that the total load shown in the schedule exceeds the total rated output of the transformers. The transformer equipment for station No. 3 was purchased with the idea of operation at overload.

The miscellaneous power load of 980 hp. covers the allowable capacity of all power centers on the various floors of the new building. This power is used in driving of all sorts of heavy duty lathes, millers, planers,

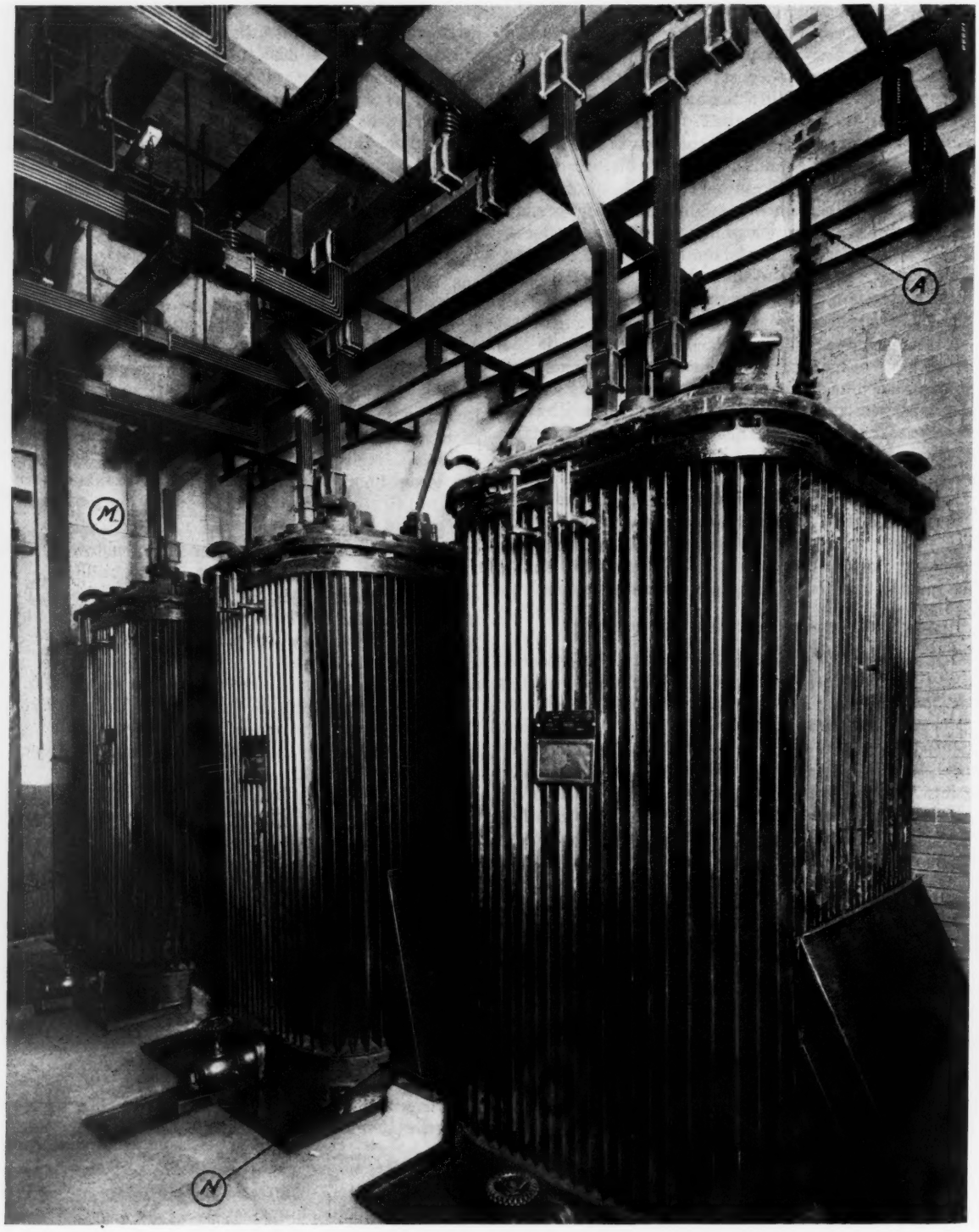


FIG. 3. BANK OF THREE 500-KV.A. TRANSFORMERS AND CONNECTIONS

Up until the present time the highest load that has been imposed on this equipment does not exceed 75 per cent of the full load rating of the transformers.

shapers and some few presses. The power distribution is made from eight main centers, located two to the floor. The feeders between the power centers and the low volt-

age distribution board in the transformer station are all run in exposed conduit and terminate in large sheet steel splice boxes conveniently placed adjacent to the power centers. The power centers in themselves are nothing more than slate panels that contain the proper size three-wire mains from which fused three-wire branch circuits are led off to the respective motors or groups of motors, as the case may be. The power feeders for the first floor centers have an average connected load of 280 hp. per feeder, per center. For the power centers on the second, third and fourth floors the feeders pass through and supply energy to three centers each, the load on each feeder being about 225 hp.

Because of the short distances in most cases between the receivers and the transformer station it has been possible, with few exceptions, to limit the feeder copper to three-wire lines of 300,000 cm., 400,000 cm. and 500,000 cm. With the use of sizes of copper enumerated, the combined drop due to reactance and resistance has been kept well within a 3 per cent limit.

To serve the load outlined in the foregoing paragraphs, it is necessary to collect the conduits carrying the various feeders at some point and direct them into the transformer station switchboard. This has been done on the ceiling of the first floor of the new building. Because of the closeness of the cranes to the first floor ceiling, racking of the feeder conduits could not extend more than 9 in. below the ceiling. At a point on the first floor ceiling immediately opposite the transformer station, all of the feeder conduits enter a large shallow sheet steel box. From this box the feeders continue into the transformer room, terminating at the switches appointed for the control of the respective circuits.

Transformer Station No. 3

Transformer station No. 3 is located at a point about midway along the west wall of the new factory building and is erected adjacent thereto. The station is a one-story brick affair, occupying an area of 770 sq. ft., measuring 27 ft. 6 in. in width by 28 ft. in length. The station is provided with an unusually high ceiling, being 18 ft. in the clear. In most instances, ceiling height is a matter to be sought for in the design of transformer housings, but in this instance the high ceiling proved to be a distinct disadvantage. By observing Figs. 2, 3 and 4, it will be noticed that the heavy low voltage bus structure is not attached directly to the ceiling but is supported by a lower sub-structure that is in turn hung from the main ceiling.

In laying out the station, it was found that the minimum head height required for the equipment would not exceed 12 ft. 6 in., but if the bus was to be attached to the ceiling directly, all of the heavy copper in the bus connecting straps would have had to have been considerably increased in length. Because of this circumstance, it was decided to put in the supports shown and, in that way, shorten the copper.

In constructing the station, the main ceiling was made to match up the ceiling of the first floor of the main adjoining new factory building. This was done so that a roadway, out of the second floor of the new building, could be built on the roof of the station. As the station building is entirely fireproof and has no windows, vault lights of heavy glass were placed in the concrete roof slab to admit natural light. The positions of these blocks of glass are such that vehicles in passing over the roof of the station do not interfere with them. The vault lights referred to are shown in Fig. 5.

Equipment of the Station

The transformer equipment of station No. 3 consists of one bank of power units. These transformers, three in number, are of Wagner make, single-phase, self-cooled, oil-insulated and of indoor type, having 500-kv.a. capacity each. Each unit occupies a floor area of 24 sq. ft., the base measuring 65 by 53 in. The units are 9 ft. 5¼ in. in height measured from the floor to the tops of the terminal bushings; the cases are 8 ft. high. As shown in Fig. 3, each unit is provided with oil level, thermometer and a large draw-off valve. Depressions

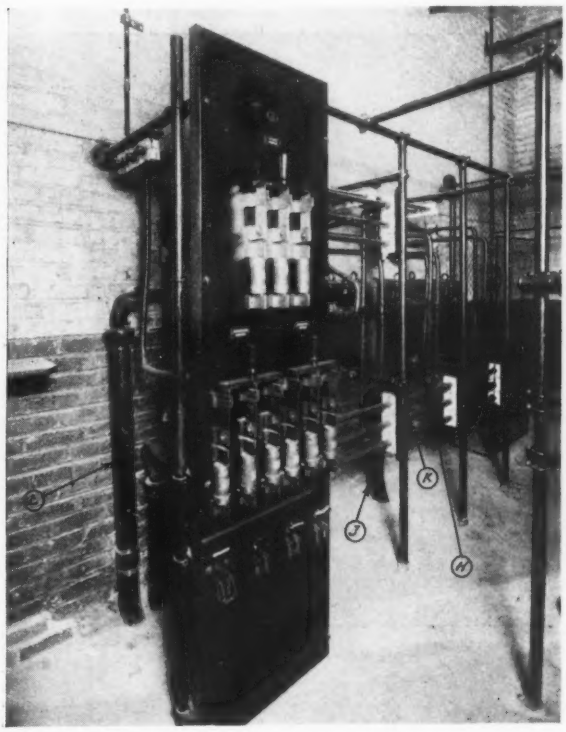


FIG. 4. SINGLE-PHASE LIGHTING EQUIPMENT

have been made in the floor to permit placing a container under the drawoffs if desirable. To prevent the leakage of oil about the floor sheet steel pans have been placed under each of the transformers. The windings are designed for a primary nominal voltage of 13,200 and the secondaries deliver current at nominal 230 v. The units are connected in delta. Figure 3 shows how this connection is effected with heavy laminated strap copper. Directly back of the low voltage bus and, run in the same plane, is the high tension bus which is made up of single conductor insulated copper cable supported on high voltage insulators. This bus is shown in item A, Figs. 2 and 3.

For ventilating the station, a system of blown air is employed. A steel flue extends up through the roof at one end of the station and is arranged to draw fresh air in from the outside. The air is pulled down through the flue and passes in through a concrete duct under the

transformers. At each transformer a connection is made with the concrete duct by a pair of leaders. These leaders, or smaller flues, direct the air up along the sides of the transformer cases and expel it into the room. To create a suction in the station a disk fan is operated at the opposite end of the room up close to the roof. This fan pulls the heated air out, exhausting it to the atmosphere. While the fan used is only a 36-in., it noticeably reduces the temperature of the inside air even in summer weather.

Items "M" and "N," Fig. 3, direct attention to the features of the ventilating system, showing respectively the duct from the outside and the flues at the transformers.

For transmitting current from the transformers to the main low voltage switchboard, several sets of busses are used. One set of busses is provided immediately

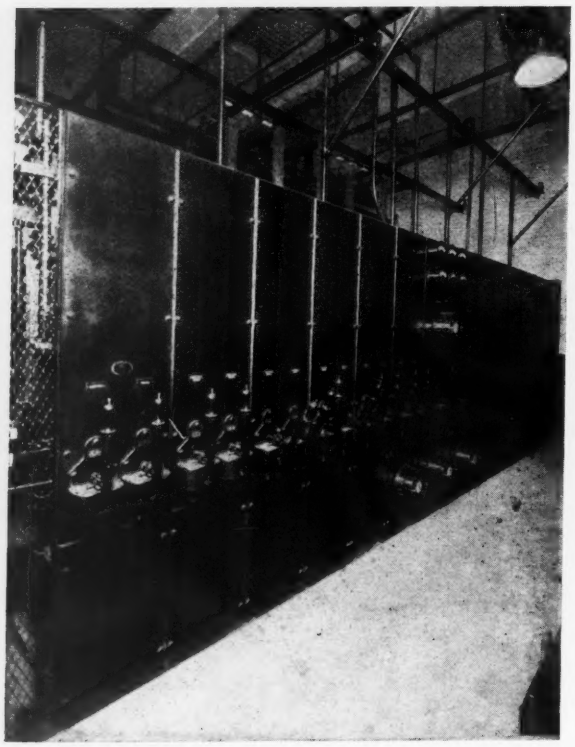


FIG. 5. LOW-VOLTAGE SWITCHBOARD

above the transformers to effect the delta connection of the three single-phase units, another set of auxiliary busses is provided adjacent to those mentioned, to receive the total current from the transformers after the delta connection is effected. From the last mentioned busses three distinct taps are made through heavy laminated copper strap for serving the three groups of load taken care of by the main low voltage switchboard.

In Fig. 2 it will be seen that two sets of three-wire busses connect through heavy disconnect switches with the switchboard; these serve the general power bus on the switchboard, and the welding bus on the switchboard. It will be noticed that the third set of three-wire connections pass directly into the switchboard without the interception of any overhead disconnect switches. These connections serve the section of the main board that takes care of the lighting balance coils. The disconnect switches mentioned along with their connections are shown in Fig. 2, item B.

On the main distribution switchboard, 12 circuits are fed from the general power section, 8 from the welding section, and only one from the lighting section. There is only one circuit for the lighting section because this circuit directly feeds the group of balance coils shown by item "H" in Figs. 2 and 4.

In observing the cuts showing the parts of the station, it is interesting to note that all circuits and connections that leave the switchboard by way of the feeder breakers are underground, while all connections within the station are made overhead. This assumption, regarding the connections, is true except for the lighting balance coils. That this arrangement occurs is not accidental, but was so arranged to prevent the multi-crossing of conduits under the floor.

The main low voltage distribution switchboard is constructed of plain black oil finished slate and consists of 12 panels. The board is 7 ft. 8 in. high and the panel material is 2 in. in thickness. As will be noted in Fig. 2, the switchboard is constructed in two parts with an aisle separating the remote controlled switches from those directly mounted at the rear of the panels. The switchboard proper is built up on a channel iron base which was laid in the concrete floor when the building was constructed. The general framework for the support of the panels and for the switch equipment of the remote section is of 1¼-in. pipe, all of which is put together with approved fittings. The entire framework is self-supporting and is tied into the building construction along the front only to insure rigidity.

From the control of each feeder leaving the switchboard a three-pole full automatic oil circuit breaker is provided. These breakers are of Condit manufacture. The entire equipment of breakers, both the remote mechanical controlled and those immediately back of the panel slate, are mounted on pipe framework that is independent of the panels. The breakers are fitted with laminated brush contacts having auxiliary arcing contact tips. The mechanism of the breakers is such that it prevents their being held closed on overload. The position of the breaker handles on the front of the panels gives indication as to whether the contacts are open or closed.

For operating the overload trip coils, two of which are provided for each oil circuit breaker, each feeder is furnished with two current transformers placed on the load side of the breaker.

Instrument equipment for an installation of this character is not extensive. Only such instruments have been provided as are necessary to give operating information about the station. On the totalizing panel, located at about the center of the board, are three ammeters, one voltmeter, one power factor meter and one indicating wattmeter. These instruments are all surface mounted, 7-in. round pattern and of Weston make. The ammeters are connected one to a phase and have a range of 6000 amp. The voltmeter has a range of 300 v. and is equipped with a switch so that voltage can be read across any phase. The indicating wattmeter has a capacity of 2000 kw. and is of polyphase type. The power factor meter is of polyphase type and is fitted with a scale marked .30-1.00-.30. The extremely low limits given the scale on the power factor meter are

necessary on account of the low power factor that the welding load often imposes on the station.

All of the indicating meters are operated by current transformers placed in the main connections just after the delta connection at the transformers is effected, and ahead of the point where the connections are again split to feed the light, power and welding sections of the switchboard busses. By so placing these instrument transformers, readings taken on the indicating instruments apply to the entire station performance. The large instrument transformers mentioned are plainly shown in Fig. 3, just to the left of the center of the view. For obtaining the total amount of energy used by the three sections of the load Sangamo polyphase integrating watt-hour meters are provided. These meters are shown in Fig. 5. The meters are those located at the bottom of the panels. They are operated by three sets of current transformers, one pair of which is provided and connected into the respective lighting, power and welding sections of the switchboard busses.

In order to check up the total amount of energy used by the station as a whole, a totalizing watt-hour meter of polyphase type is provided on the totalizing panel. This meter is of Sangamo make and is shown in Fig. 5 just below the ground lamps. The capacities of the various integrating watt-hour meters is of interest, as the figures are indicative of the loads handled by the different sections of the switchboard.

SCHEDULE OF INTEGRATING WATT-HOUR METERS

Total output meter.....5000-amp. current transformers
Power meter .....4000-amp. current transformers
Welding meter .....4000-amp. current transformers
Lighting meter ..... 500-amp. current transformers

Transformer station No. 3 provides single-phase lighting through the medium of three 25 kv.a. balance coils which are shown in Fig. 4, item "H," and Fig. 2, item "H." These coils are connected in delta on the 220-v. side across the three-phase power mains. As will be noted in the figure, the supporting framework for the coils is also used in supporting the cables forming the connections between the coils, and from the coils to the knife switches on the panel from which the single-phase distribution is made. Connections between the oil circuit breaker on the main switchboard and the coils are made with three 700,000-cm. rubber covered cable run in one 3½-in. conduit, underground. This conduit is shown in Fig. 4, item "J." Between the coils and each knife switch a single-phase, three-wire, 220/110-v. connection is made in three 500,000 cm. cables extended in open work on the supporting rack. See Fig. 4, item "K." Item "L" in Fig. 4 shows one of the lighting feeders leaving the lighting switch panel, in its course to the lighting centers in the new factory building.

For entirely severing all connections between the low voltage switchboard and the transformers, disconnect switches having laminated blades are used. These switches are fitted with automatic locking devices that prevent the opening of the units in case of short circuit on the system. Normally, these switches are easily operated from the floor by means of a pole equipped with proper type hook. The switches are of 4000-amp. capacity, each bus connection being fitted with one single-pole unit.

At the front of the low voltage switchboard an operating space of about 5 ft. is maintained. This area opens through a door into the first floor of the adjoining factory. To prevent anybody, having gained access to the operating space, from going farther into the station, a wire grille fills in the space at the ends of the switchboard. This grille is made of No. 12 gage galvanized iron wire laid off in 1¾-in. diamond meshes, and is arranged with locking gates at either end.

In looking at Fig. 2 one will notice that the end wall of the station is done in brick. There is a substantial reason for this. This station, like its predecessors, will be outgrown and to take care of this probable expansion it is intended to extend the station by removing the brick wall in question. In case expansion in this station is necessary, the switchboard can be lengthened and another bank of transformers can be placed along the same side as the present bank now occupies. In Fig. 2, item "C" shows the non-automatic high-tension oil switch which controls all high tension current to the station. This switch was installed by the local lighting company. The end of the station opposite the brick wall is provided with a large fireproof rolling door, covering an opening that is large enough to permit the removal of the transformer units without dismantling.

This station has been in operation since the summer months of 1920 and has functioned very satisfactorily and without mishap. Considerable credit is due those associated with the project. The station was not constructed under the most advantageous circumstances. All kinds of trouble were experienced in obtaining materials, the course of construction weathered many labor strikes and finally the station had to be placed in operation long before it was fully completed.

Without the hearty co-operation of the owner's engineers, the serving company's construction department and the sincere earnestness of purpose put forth by the contractor, this project would have been anything but pleasing. The station was built by the United Electric Construction Co., equipped by Lewis & Roth and designed and supervised by Ballinger & Perrot, all of Philadelphia.

IN ONE English station, a large atmospheric pressure heater composed of old boiler drums has been placed in the gas passage on the chimney side of the economizer, and receives all clean drip water, including blowoff from safety valves. Condensate from the turbines passes first through a low-pressure economizer which has served its useful life, then to the open heater, which has a storage capacity of 100,000 lb. of water; the boiler feed is taken from the heater and pumped through the high-pressure economizer to the boilers. Flue gases are reduced to 220 deg. before being sent to the stack by induced draft fans.

ELECTRICAL MACHINERY DIVISION in the Bureau of Foreign and Domestic Commerce will be headed by R. A. Lundquist, according to announcement recently made by the department. This is one of the new industrial divisions made possible by Congress through the export industries act. It is planned to secure the services of experts to specialize in the more important export products. Appointments in the iron and steel, lumber and heavy machinery division have already been announced.

Europe Enters Period of Steady Development of Power Industry

ENGLAND STUDIES TIDES; FRANCE, SWEDEN AND FINLAND TURN TO HYDRAULIC POWER SITES; ITALY AND GREECE MAKING FURTHER USE OF WATER POWER. BY L. W. ALWYN-SCHMIDT

EUROPE, as regards the power situation, has now emerged from the chaos of the reconstruction period and begins to shape its new course in the direction of a steady development upon the basis of the experience of the last few years. These years have shown that the use of power holds greater possibilities than merely those of supplying energy to machinery. Power has replaced thousands and thousands of toilers. It has taken away their jobs, as it looked in the early days of power application; has set them free in truth, as we realize it to be today. The drudgery of former days when workmen were expected to work 11 and 12 hr. every day for a pay much below that of even the lowest paid workers of today has given place to a system of production carried on in sanitary surroundings where the principal work is done by machinery, tended only by the men. Instead of enslaving the industrial worker, the power industry has shown the way to shorter hours and more pay.

With the application of industrial power, the industrial system has become of new significance. Industrialism is working itself out in a new direction that could not be expected when it first came into appearance. It may, in fact, solve in the near future many of the social problems that still bother our economic existence of today.

POWER INDUSTRY ABATES SOCIAL UNREST

NATIONS BEING confronted by a form of social unrest that has put in an appearance during the war but has its causes in a situation existing as far back as the middle of last century, are facing this situation today with new possibilities. Attempts are made to correct the mistakes of the present system by correcting those of its economic causes that can be corrected during our present state of industrial development.

Centralization of power production and supply put into our reach by the birth of electricity, or rather by the knowledge of transmitting power by electrical means, is studied with a view to lessen the employment of human energy and, by doing so, make work easier. The question of nationally controlled power sources is considered more intimately so that these sources may be developed to the best advantage of the national industries. Private capital is encouraged to aid in this development but at the same time steps are taken to minimize the danger of individual control of the power sources by putting this control in the hands of the nation. This is done by either nationalizing all power sources or by making their utilization subject to national supervision.

Ideas still differ about the most practical means of carrying all this into effect. But such difference of opinion does not hinder the progress of the work itself. Its principal aim in each country is to make productive first of all those power sources that are cheapest, second to eliminate those sources which are still expensive because uneconomical in operation, and third, to bring power in small units to all those that can use power conveniently. Incidentally the attempt is made to eliminate all waste in the production of power itself by placing the principal power sources in such parts of the country, where production can be carried on to best advantage and to leave the retailing of power to local distribution stations.

The solution of the problems involved is approached differently in different countries according to their national temper and national practices. In England there appears an increasing tendency for city ownership of distribution or private distribution companies under close municipal surveillance, with the nation taking charge of the super-power stations to be erected in suitable parts of the country, these super-stations to be built either by national means or by the aid of capital subscribed by individual municipalities.

In France, nationally owned power stations, serving directly a large region without the intermittent aid of private or municipal distribution stations, seem to be mostly desired. The cause is the comparative centralization of the power sources in one part of the country while the whole western section is still better suitable for the erection of smaller plants serving limited distribution regions. In Germany, national and municipal control is becoming rapidly predominant under the influence of a system of general socialization of fundamental industries already started in the time of the old regime.

In Italy national, municipal and private control are still in use with no special tendency having developed at the present time. The reflex of European experience is clearly shown already. In Canada municipal and private ownership dwell friendly together. In New Zealand public ownership of all power stations is more or less an accomplished fact, while in India the colonial government is responsible for most of the leading projects. In the United States, again, private ownership under the control of public service departments seems to work best.

It must be the duty of all those interested in power development to hold the development of this industry for the next few years at least inside the boundaries prescribed by these aims so that it should not again be thrown out of a development which has proved itself to be of eminent usefulness during time of need. The experiences of the war are now to be applied to the conditions of peace.

It is interesting to see, how in each country, power engineers work hand in hand with the authorities to execute these lessons of the war and to use this new interest in power development for the purpose of carrying the development of the power industry as far ahead as its present impetus will allow. Engineers find in this work a fertile ground in the power consumers themselves. The industries in each country have realized that they cannot expect to compete and develop successfully without the aid of cheap and sufficient power. Public and private funds, therefore, are sitting loosely whenever the collection plate is handed around for subscription of new capital and the amount of money coming forward for power development during the last two years is quite astonishing, considering how public and

private funds were squandered on less productive enterprises during the excitement of the war.

Incidentally the search for cheap and economic power sources has led to the re-opening of such controversial problems as that of using wind power for the purpose of electrical power generation and tidal power. As regards the latter, an interesting interim report, the third one in line, has been published recently by the British Board of Trade Water Power Resource Committee. This report is probably the first in the world that deals seriously with this important question and has under consideration a number of actually worked out projects of which two in the Severn Estuary have found the attention of the committee.

Use of Tidal Power in England

The committee points out the importance of inquiring into any sort of power project which does not require coal for the generation of power. While there seems to be no doubt about the technical possibilities of using the tides for power generation, there is nevertheless noticeable a considerable lack of sites where the plants can be operated commercially, securing a profit to the undertaking. The possibilities of using the tides of the Severn are taken as a test question. The conditions in that section are almost ideal for an experiment and the adjoining districts are offering a practically inexhaustible market for power. The committee proceeded on very original lines, making a complete investigation in which it started by approaching various makers of low head and variable head turbines in the world with a view to obtain prices and technical data. The result of this inquiry showed immediately that the actual knowledge of this branch of power development was still very small among the designers, and the estimates that were obtained have to be accepted upon the supposition of a larger percentage of error.

On the other hand, much valuable aid and suggestion came from this general inquiry and the committee states that upon the basis of the information obtained it is able to state that the project might be carried out with a reasonable expectation for commercial success. The committee, in consequence, has come to the conclusion that while at the moment no conclusive opinion can be rendered, the problem should be studied further and more intimately. It recommends, therefore, the active participation of all those interested in power generation in the solution of the various problems, suggesting that such investigation would certainly lead to a satisfactory solution of each controversial point.

The committee, being of a more general character, in consequence calls for the formation of a new and more specialized body for the purpose of inquiring specifically into the possibilities of the Severn project. As to the general findings, these are of considerable interest because they show the way in which this question should be approached in other countries. The committee is of opinion that the difficulties of harnessing the tidal powers are so bound up with local conditions that it is necessary to approach the general question of tidal power always with reference to actual conditions obtaining in some particular neighborhood.

As to the special case of the Severn project, the committee found that the project will want some more technical development before a final pronouncement can be made. It is estimated, however, that the power obtainable would be sufficient to replace up to 2,500,000 tons of coal every year. This energy could be used by industrial organizations in the Midlands, in Wales and by new establishments to be placed on the banks of the Severn. It is probable that developments of any specific power scheme can be combined with proposals for improving transport and shipping facilities. In such cases, the whole project should be considered as one.

Before a definite pronouncement can be made in regard to the commercial practicability of any proposal, a number of physiological, engineering, commercial, industrial, and economic investigations need be carried out. The prosecution of such an inquiry would require the close collaboration of experts skilled in the several branches of engineering and science involved and the carrying out of experimental investigations and of certain hydrometric surveys.

England, therefore, has started upon the road to a utilization of tidal water powers. It may still take several years before the present project has been actually started but the use of the water powers of the tide will be an accomplished fact in the present life of men after it has found utopical discussion since so many years. In the meantime steps have been taken in England for a further centralization of the power generation by creating a joint power authority for the large district, including the city of Liverpool and a great many other important industrial centers in South West Lancashire.

This project is typical for a great many others now under consideration in England and it shows very clearly in which way the development lies at the present time in that country. The Liverpool plan has been worked out originally by mechanical engineers. It contemplates the erection of a large power station somewhere on the Liverpool riverside. This capital station is to start with four substations of a development of 25,000 kw. each. Additions will be made from time to time until a complete development of 250,000 kw. is accomplished. The total cost of the first stage of the scheme is estimated to be $22,000,000, which shows how freely money is spent just now in England for power centralization.

The total population of the area reached by this station is in excess of 1,500,000 and the whole district is literally covered with industrial enterprises of all sorts. The money for the station is to be supplied from the national treasury. If the scheme is approved by the authorities and there seems little doubt for that there will not be any waiting until the capital is collected from private sources but building may begin immediately.

Big Investments Go Into French Power Development

The interest taken in electrical power development in France is best illustrated by the fact that not less than 450,000,000 francs were invested in power enterprises during the last 3 yr. in that country. For this amount, France has purchased 49 new power stations and has laid the foundation to a scheme of power development which in the near future will produce 4,000,000 hp. of its water power resources only. Of the new projects 500,000 hp. are expected in the near future and the complete development will be available by 1934

approximately. Typical for the modern French power stations is the new central of the Societe Hydro Electric in Lyon at Seyssel, Haute Savoie. This station is supplied by four generators each of 5000 hp. capacity, but the total development will finally be 27,000 hp.

France is considering this question of national power development also from the point of view of making navigable its inland waterways. The Rhone for instance offers great possibilities in this respect and a combination of dams and locks for the improvement of electrical power. The main significance of the present development for France lies in its possibilities of supplying smaller industries with power of some sort. France has still many minor industries which use none or only little power which, however, might be readily developed if cheap power could be supplied to them in small quantities. Electricity is offering this possibility and hand in hand with the development of the water power of France, therefore, goes a campaign for the modernization of artisan industries. This adds to the wealth of the country and brings also the required customers for the electrical power stations. All in all a rather ideal combination.

Power Development in Northern Europe Grows Rapidly

In the north of Europe, Sweden and Finland provide at present much food for thought and discussion. Sweden is a comparatively small country as states go in our own part of the world. For so small a country, however, Sweden possesses a great number of natural power sites of which only the most promising have been developed so far. The operation of the central power stations of Sweden apparently is a very good source of income and the soundness of the situation is well known by the fact that the total income of the Swedish electrical power stations has remained around $3,000,000 during the last years. The distribution lines in the cities have grown from 2960 kilometers during last year to 3425 kilometers during the present, while the country distribution lines have remained 1150 kilometers of length.

There are 24 secondary stations and 270 tertiary stations. An extension of the water power supply is contemplated for the near future with the regulation of the waters of Lake Vaner. Sweden has taken in hand the electrification of its country district upon a scientific basis. It was found that a district having at least 30 per cent under cultivation can be developed with a reasonable expectation for profitable operation. During the war, districts having only 25 per cent under cultivation have in fact been developed with success.

The experience of Sweden has had a good influence upon the electrical development in other North European countries and the Swedish system is to be copied in Finland. In Finland today 32 districts exist that fulfill the Swedish standards, and of these 17 have already been developed. Until recently only two of the Finnish power plants catered for agricultural districts and both are working with a much smaller percentage of cultivation than those demanded by the Swedish standards. The Agricultural Producers' Central Union has now taken steps to encourage the development of other districts and as the result a new rural power plant has been put into operation in the Abo province. This plant is the Sallila Sahkolaitos O. Y. near the Wampula Church in Loimijoki. It has a 300-hp. turbine which is fed by a six-meter drop of water.

Low tension current of 380 to 220 v. is used in the neighborhood and 20,000 v. for long distances. There are five step-down stations to 3000 v. and 29 outdoor step-down stations to 380 v. for motors and 220 v. for lighting. The transmission equipment consists of 43 kilometers of 20,000 v. cabel, 47 kilometers of 3000 v. cabel and 80 kilometers of low tension wires. These are all of copper. The plant is called typical for the requirements of a Finnish country central station. A similar station was erected in the Vihtis district. Both these plants were installed and erected by the Hankkija Society of Helsingfors.

Italian Development Impeded by Lack of Capital

In the south of Europe, Italy continues to provide a power problem for which there is no ready solution. Italy is short of good steam coal and barring some great discovery of coal beds in Italy, which is not very likely, there are no other means of providing Italy with coal than by importing it. But the war has shown that Italy can get along with considerably less coal than was imported in the past, and given a little time and peace, Italy may correct its present economic situation by simply replacing the power drawn from imported coal by power drawn from other sources, as water or wind.

What this means to Italy will readily be understood if it is realized that Italy had to import approximately 12,000,000 tons of coal every year which came nearly entirely by water from England. Inland transportation was not of much advantage, which also is the explanation why Italy is not particularly benefited by the coal it is supposed to receive from Germany as part of the reparation payment. Italian lignite is of comparatively low grade and cannot be used as a substitute for coal as is the case with German lignite in certain districts. Hence there is no possibility to turn the lignite coal power into electrical power by the use of large electric centrals.

The question of making use of water power is, therefore, very urgent in Italy and the development of hydroelectric sites has found a great stimulation during the war; 9,000,000,000 lire approximately were invested in water power development in Italy during the war, bringing the invested capital to 1,500,000,000 lire approximately. To the existing development 265,000 hp. was added and there is now under construction 400,000 additional hp. for which 1,200,000,000 lire will be spent. Italy looks for help to the United States where it is hoped to find advice and money for the future development of its hydroelectrical enterprises. Considering that plans are laid to develop another 1,000,000 hp. there should be sufficient inducement for investing both capital and machinery in ventures of this kind and our banks might be well advised to give some attention to this feature of the Italian power situation.

Greece is situated nearly as badly as Italy as regards the supply of coal although it is somewhat nearer to the Asiatic coal fields and other fuel sources than its more western neighbor. But the question of developing the Greek water powers is not less active at present in Greece. An investigation of the more promising sites has shown that there are good opportunities for using water powers on the rivers Kladovo, Vodena, Niaoussa

and Aliakmon. The biggest possibilities are found on the last named river where two falls provide 143,000 hp. each. The total available force is estimated to be 350,000 hp. One hundred and twenty million kilowatts might be supplied by developing these sites at a cost of $34,000,000 approximately. In Athens and the Piraeus, 40,000,000 kw. are consumed approximately every year and Saloniki requires 9,000,000 kw. To secure a uniform development the Greek Government has expropriated all water power rights in Greece, but is open for offers from private investors for the development of individual projects.

The general situation of the power industry has been much improved in Europe during the last three or four months and the electrical industry at least has not felt so severely the economic depression that has been characteristic for many other industries during the first four or five months.

Impractical Boiler Connections

TWO BOILERS INSTALLED WITH DANGEROUS BLOWDOWN, FEED WATER AND GAGE COLUMN CONNECTIONS. BY GEORGE C. STIERHOFF

HERE IS a specimen of boiler connections found by boiler inspectors. An old experienced inspector was called upon to make the first inspection of a boiler that had just been installed. The engineer and a helper had done most of the work of setting and connecting up these boilers. He felt very proud to acknowledge that he did not have to call upon the assistance of a consulting engineer in constructing this plant. By the manner in which the boilers were connected it was evident that he should have consulted someone that knew a little more about the connecting up of a boiler than he.

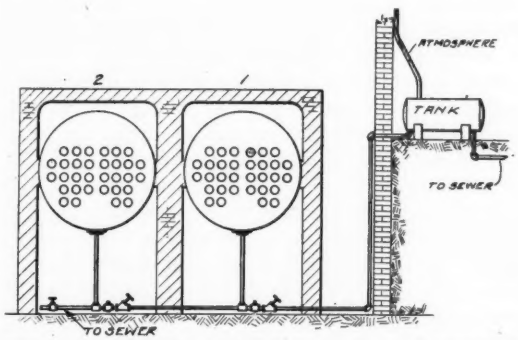


FIG. 1. BLOWOFF CONNECTIONS FOUND BY INSPECTOR

The drawings are from sketches made by the inspector. Fortunately these boilers had not been put into service, or perhaps serious damage might have resulted.

The boiler blowdown piping was connected as shown in Fig. 1; there was a 2-in. extra heavy blowdown pipe from the boiler into a tee, then to a plug cock, and boiler blow globe valve. He then connected this so that to blow No. 2 he would have to open up the cock and valve on No. 1 boiler, thereby having both boilers blowing at one time, as they were both connected on one line. This, of course, was impractical and not in accordance with the law. This boiler was then connected to a blowdown tank situated outside of the boiler room at an elevation of about 10 ft. above the boiler blow valve. This formed a water pocket and had it been allowed to stay, might have resulted in serious water hammer, bursting the pipe, and perhaps scalding those nearby. There was also a separate connection from boiler No. 2 with a valve and drain pipe leading into a sewer which was claimed to be used for draining the boilers when taking them out of service.

Even more stupid than this was the manner in which he had connected up the boiler feed and water column connections. Here he had the feed line connected to the lower end or properly the drain connection of the column

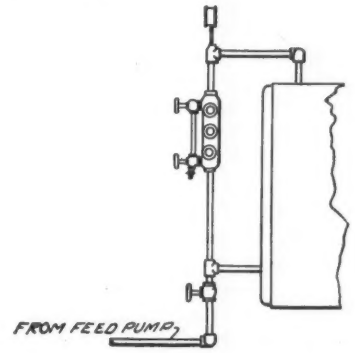


FIG. 2. DANGEROUS GAGE COLUMN AND FEED PIPE CONNECTIONS

as shown in Fig. 2; this he said afforded a better circulation to the water.

These connections had to be changed to comply with the boiler law, without wasting more material than necessary. This was done too by purchasing a few valves and fittings which should have been installed originally.

It was then suggested, and the plan accepted, to place the boiler blowdown tank in the corner of the boiler room. The two tees in the line were plugged at the end, and the connection from No. 2 boiler entered the

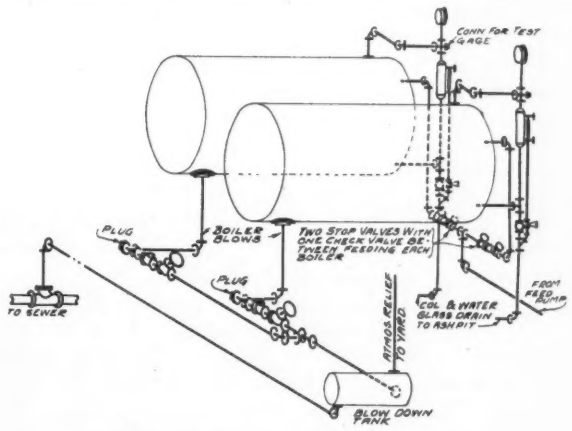


FIG. 3. REVISED BOILER CONNECTIONS

line leading to the tank through a tee, as shown in Fig. 3, which allowed either boiler to be blown down independently. A line from the tank was then connected to drain into the sewer connection, and the tank was also connected by an atmosphere relief pipe to the yard.

In front, the boiler was connected up properly by draining the columns, and water gage glasses to the ash pit. The boiler feed line was connected with a line

feeding the two boilers, each boiler having two globe stop valves with a check valve between.

These connections were made, utilizing practically all of the original material and this arrangement was passed by the state authorities.

Leakage in Surface Condensers

CAUSES OF LEAKS AND METHODS OF DETECTION. BY GEORGE C. COOK

IN the majority of cases where surface condensers are used, the water used as a cooling medium is not of a desirable character for use in the boilers, due to its tendency to cause corrosion or form scale, consequently leakage of the circulating water into the condensate is to be guarded against as insurance against trouble in the boiler room. Contamination of the condensate is caused by leakage through tube packings, pin holes in the tubes, and split or broken tubes. The first two causes are the most usual, but cases occur of continued tube failures due to poorly annealed tubes, tubes crystallized by vibration, expansion stresses in tubes gripped rigidly by corroded packings, and tubes weakened by corrosion from electrolytic or chemical action.

Split or broken tubes are detected at once by the increased quantity of water in the hot-well and a noticeable loss in vacuum. The procedure in such a case is to pump the condensate overboard until the unit can be taken out of service and the tube or tubes plugged. Tapered wooden plugs are best to use and are driven tightly into the openings at each end of the leaking tube. It is desirable to replace the damaged tubes at the first opportunity presented for getting the unit out of service a sufficiently long time.

While excessive leakage from the foregoing cause is at once apparent, leakage from faulty packing or pinholes in the tubes may be of considerable amount and go undetected unless steps are taken to guard against it. Leakage from this source may be causing scale or corrosion in the boilers and introduced at this point it is much more difficult to remedy it by chemical means than where the impurities are introduced with the make-up water. With some systems of water softening it is possible to counteract this effect by the introduction of an excess of softening reagents with the make-up water; but the objection to this procedure is that there will be a precipitation in the piping and heater. The proper method of operation is to keep the leakage at a minimum at all times.

By means of suitable tests, the presence of leakage into the condensate may be detected and its amount determined even when very minute. The tests which may be employed are of two classes, chemical and electrolytic. Of the chemical tests, the silver nitrate determination for chlorine is about the only one sufficiently accurate to determine small percentage of leakage and at the same time simple enough for the use of the station operator. This test is adapted for use only with installations where the circulating water has a high chlorine content as, for instance, where seawater is used.

The apparatus required for making this determination consists of a small glass beaker, a graduated burette and stand, a saturated solution of potassium chromate and a solution of silver nitrate. The silver nitrate solution is made by dissolving 4.8 grains of silver nitrate in 1000 cu. cm. of distilled water. The test is made as follows, 10 cu. cm. of the condensate is measured into the beaker and three drops of the potassium chromate solution added, then the silver nitrate solution is added slowly from the burette until a faint pink color just appears, the water in the beaker being stirred at the same time. The number of cu. cm. of silver nitrate solution added is the chlorine content of the water in parts, per 10,000. Ten cu. cm. of the circulating water are taken and mixed with 90 cu. cm. of distilled water. Ten cu. cm. of this mixture are now tested with silver nitrate as above. The cu. cm. of silver nitrate in the first case multiplied by 10 and divided by the cu. cm. of silver nitrate used in the second case gives the percentage of leakage.

While the test described is quite accurate, its field of application is limited to installations where the circulating water has a high chlorine content. A method for the determination of leakage which has almost unlimited application and which is simple and expeditious is that based on a measurement of the conductivity of the condensate. It is known that the conductivity of water increases with the increase in the quantity of salts held in solution by it. It is not necessary that the absolute value of the conductivity be determined, a relative value being sufficient. The apparatus necessary is in general a U tube for holding the water to be tested and equipped with an electrode immersed in the water in each leg, a source of current at constant potential and a suitable voltmeter or ammeter. The exact arrangement and selection of apparatus may be varied to suit conditions as to voltage instruments, etc., available. One arrangement of apparatus found to give satisfactory results was as follows: A U tube 10 in. total length was used with electrodes of 3/16-in. copper wire inserted through corks into each leg. The U tube was connected in series with a direct current voltmeter having a 300-v. range and 33,000 ohms resistance across a 120-v. direct current supply from the storage batteries.

When a suitable arrangement has been devised, it is calibrated by reading the instrument with mixtures of distilled water and varying percentages of the circulating water. These readings may be plotted against the percentages of circulating water, thus giving a leakage standardization curve. Where great accuracy is desired, as for instance in connection with water rate tests of turbines, condensed steam from a bleeder in the steam lead should be used in place of distilled water in standardizing the apparatus since the pure condensate may contain a trace of salts, carried over from the boiler in the entrained moisture in the steam. Readings of the instrument may be converted into percentage leakage by reference to the standardization curve. The standardization should be repeated from time to time to take care of variations in the character of the circulating water.

In a plant operating surface condensers, it is well worth while to make the testing of the condensate from each machine a matter of daily routine. If the condensate shows greater than one per cent leakage the unit should be taken out of service as soon as possible and the condenser tested for leaks. The leaks may be

located by filling the steam space with water and inspecting the ends of the tubes in the water boxes or a partial vacuum may be formed by operating the dry vacuum pump and the leaks be detected by testing with a candle. If the packings are leaking, the glands should be tightened or repacked as the case requires, leaking tubes should be either removed or plugged.

High Cost of Sagging Insulation

PIPE COVERING MAY LOOK SNUG AND IN GOOD ORDER YET MAY BE VERY INEFFICIENT. BY S. ROLAND HALL

"HOW'S your pipe covering?"

Go into any plant and ask this question of the operating engineer, the superintendent or the mechanical engineer, and the chances are that you will be told that the pipe covering is O. K., that there has been no complaint, and so on.

Then pop another question, just for fun. Ask, "How does a pipe covering fail, anyhow?" It's surprising how many men who have to do with power in one way or another seem to have thought very little about how pipe covering does fail.

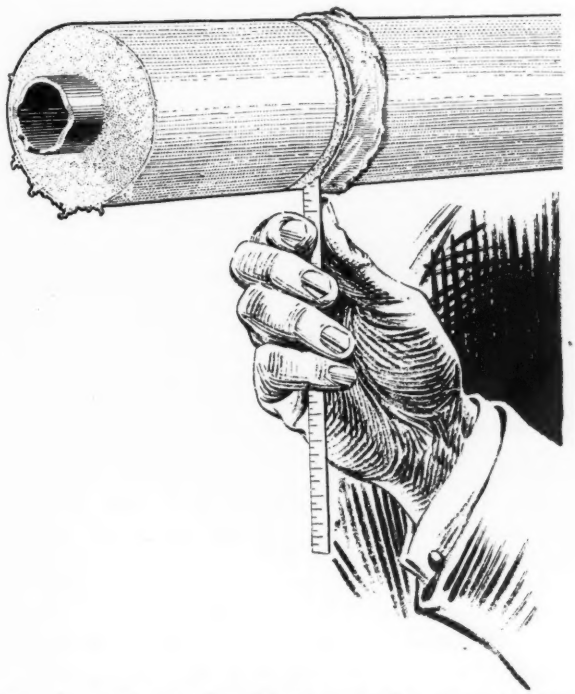


FIG. 1. TEST TO DETERMINE WHETHER OR NOT PIPE COVERING IS SAGGING

Generally, it is the impression that so long as a pipe covering looks well from the outside it is doing its work well. Of course when one stops to think about it, the outside of a pipe covering is actually no indication of its insulating efficiency unless perchance the covering is hanging in shreds, when it would be obvious that its usefulness was practically destroyed.

To illustrate: Some coverings give good results at moderate pressures and temperatures, but contain from 20 to 22 per cent of material that is inflammable when the temperature goes well up. Under high heat, this inflammable content becomes first scorched and then charred on the covering immediately next to the pipe. The volume of the covering having been thus materially decreased, the weight of the covering causes a slight sagging. Sagging, though it be no more than an eighth or a quarter of an inch, will cause convective currents, which travel to the nearest joint in the covering and escape.

Make this test on pipe covering that is easily accessible. Thrust a thin metal rule or gage up through the joint and check up your measurement with the thickness of the covering as stated in the specifications. If you find that there is a distinct sagging of the covering,

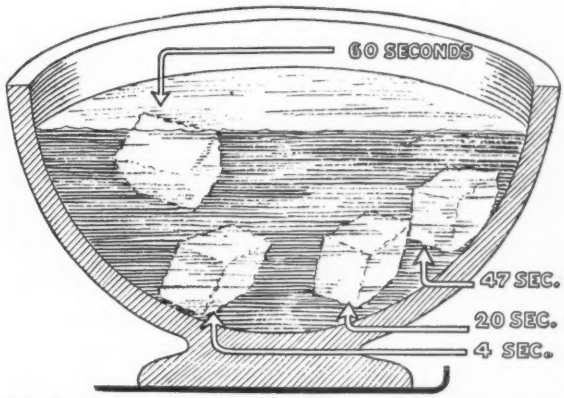


FIG. 2. TEST OF CUBIC INCH PIECES OF DIFFERENT PIPE COVERINGS SHOWING THE VARYING DEGREES OF CONNECTIONS BETWEEN THE AIR SPACES AND PORES.

then it is a sure thing that the insulating quality of the pipe covering has been largely reduced and is probably losing to the plant every year the cost of really efficient pipe covering.

There are pipe coverings that heat does not affect except to make them slightly more efficient. These cannot carbonize or oxidize.

There are several things to consider in choosing a pipe covering: insulating quality, weight, strength. Weight is a detriment and should be no greater than is necessary to secure needed strength. A certain strength is essential, but this should not be carried to the point where insulating quality is reduced. It is easy to construct an extra strong pipe covering, but nothing is gained by so doing unless the full insulating quality of the covering is maintained.

There are coverings that are extremely light and yet rigid, so that they adhere snugly to pipes. There are coverings that have enough strength for all practical purposes and at the same time retain a high insulating efficiency under high temperature. These don't sag.

Check up the sag on your pipe covering. You may learn something that you will want to correct without delay.

After Hidden Facts

DEACON: "Well, Scipio, now dat yuh am a full-fledged powah house man, does yuh do any research work?"

Scipio: "Does I? I'll bet I'se spends foah hours ebbery day a huntin' foh mah tools."

Constructing a Sheet Metal Elbow

PRACTICAL METHOD OF LAYING OUT PATTERNS FOR IRREGULAR SHAPES. BY F. WEBSTER

WORK OF the construction engineer is not limited to "nutting," as the operation of putting the nuts on bolts in the mill is called. His initiative is often stressed to the utmost, and he finds ready use for many of the "tricks" of the numerous trades and professions. A case in point is given herewith, Fig. 1, where it became necessary to construct a special elbow connection that had both a twist and an offset.

The laying out of patterns for the various constructions made of boiler plate or of lighter metals, which are so largely used in power stations, mills, factories, and the like, is of special interest to the builders and operators of power plants owing to the great variety of these constructions. To make patterns successfully for plane, curved, twisted, or warped surfaces, and for various combinations of these in one construction, requires that the construction engineer be competent to read working drawings, and it is necessary that he have a good knowledge of the geometry of curves and triangles. Also he must have a good imagination so that he can readily visualize forms that have never been made.

The following example was presented recently and is one that has both the size and the twist that make it not one of the off-hand class of patterns. Then again, it presents a case where a correct pattern will save considerable work and expense; furthermore, if the pattern is right, the designer will be saved from many a nightmare, but he may have some day-mares while producing the pattern.

The general form of this elbow or transition piece is shown in the sketch, Fig. 1. The small opening is 3 by 6 ft. and the large one is 3 by 10 ft. The long axes are at right angles to each other and the vertical center lines are offset 12 in. The rise in the throat is about 14 ft. The outline in the side elevation consists of two circular curves. Steel plates ⅜ in. thick with riveted joints are used in the construction.

The patterns for the four plates—top, bottom, right side, and left side—can be laid out on the drafting board. The sides must be made by the triangulation method and the top and bottom patterns may be made by the stretch-out method.

The first thing to do when drafting patterns of this kind is to lay off certain construction lines on the side and the front views, as shown in Fig. 2. Divide the curves on the side view into several equal parts; six are used in this case. Project these points onto the corresponding curves in the front view, and then number or letter the points so that the draft can be easily followed. Next, connect the division point on the curves of the side view with a series of solid and dotted lines. Thus, dotted lines are used to connect point 1 to 13, point 2 to 12, etc. Follow the same method on the sides of the front view. By making these construction lines alternately solid and dotted as shown, the system will be easier to follow when laying out the patterns.

The pattern for the top plate is begun by first drawing the boundary lines vertically from the edges of the front view and at right angles to these edges. On these lines lay off a stretch-out of the lengths of the arcs forming the top curve of the side view. Usually, a very close approximation of these arc lengths can be made with the dividers.

Special care, however, should be taken when developing any arc onto a straight line, as any mistakes made here may distort the pattern. Draw parallel lines connecting the corresponding points on the stretch-out lines, and then project the points from the top curves of the front view onto the corresponding lines. Note that the intersections are the locations of the curve points, and that the pattern represents the top plate when rolled out on a flat surface. Therefore, by joining these points by curves as shown, the pattern for the top plate will be defined.

The pattern for the bottom plate is laid out in a similar manner to that used for the top plate. The stretch-out of the lower curve of the side view is made below the front view on lines drawn vertically from the ends of the large openings in the front view. The horizontal lines are drawn so as to connect corresponding points, and then the division points on the lower curves of the front view are projected onto these horizontal lines. Finally the side curves of the pattern are drawn through these points that have been located on the horizontal lines. Add any extension that may be needed for flanges or laps.

The curves forming the corners of the elbow as shown in the front view are drawn arbitrarily, but when once located they become fixed curves for the patterns. It is evident that there may be many solutions of the problem, owing to the fact that these corner curves may have many different shapes; however, a single limitation may be made on the location of these curves, and one that is easily satisfied, so that, after all, these corner curves may be drawn so as to fill the requirements of the problem. For instance, suppose that it is required to enlarge the elbow uniformly. Then, the area at the middle of the length of the elbow should be equal to the mean of the two end areas. This mean area could be laid off in the proper location and the corner curves drawn through the corners of this area. If closer work is desired, other intermediate areas may be laid off and the curves drawn through the corners of all of these. The method of figuring the middle or mean area is as follows:

$$\text{Area of small end} = 3 \times 6 = 18 \text{ sq. ft.}$$

$$\text{Area of large end} = 3 \times 10 = 30 \text{ sq. ft.}$$

$$\text{Mean area} = \frac{18 + 30}{2} = 24 \text{ sq. ft.}$$

$$\text{The average height equals } \frac{3 + 6}{2} = 4\tfrac{1}{2} \text{ ft.}$$

$$\text{The average width equals } \frac{10 + 3}{2} = 6\tfrac{1}{2} \text{ ft.}$$

If these dimensions are used, the area will be $4\frac{1}{2} \times 6\frac{1}{2} = 29\frac{1}{4}$ sq. ft., or slightly more than the theoretical mean. If the section be made 4 by 6 ft., its area will

be 24 sq. ft. Of course, this middle area need not be the mean area of the two ends. In fact the enlargement of the elbow might be such as will accommodate the natural expansion of the gases flowing through it.

After drafting the patterns, templets of heavy paper or of thin sheet metal should be made from the drawings. Assemble these templets into the form of the finished structure and thus test the accuracy of the lay-

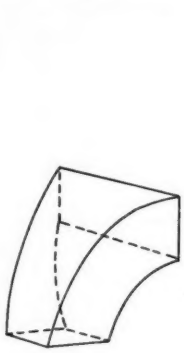
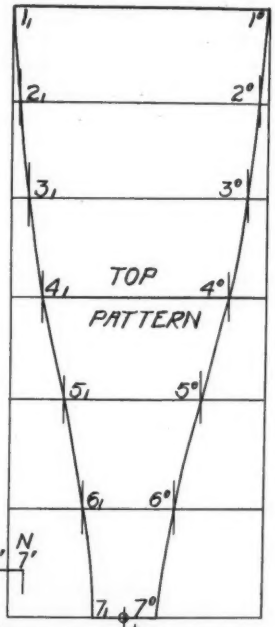


FIG. 1



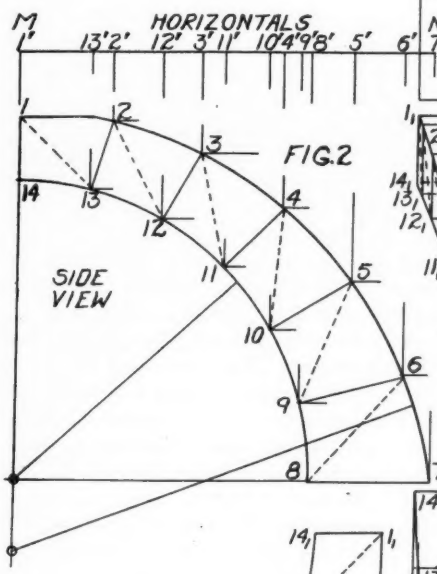
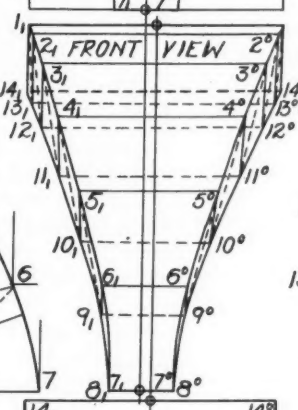
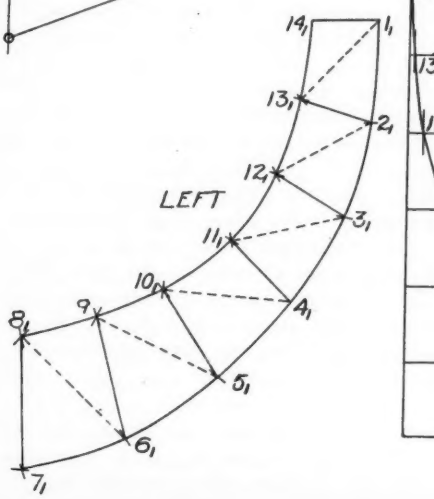


FIG. 2





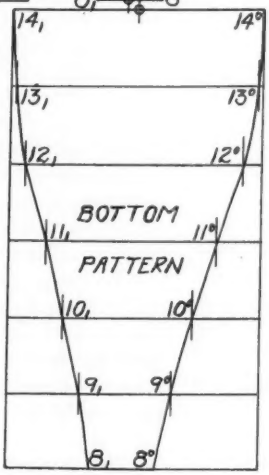


FIG. 3. PRINCIPLE OF TRIANGULATION

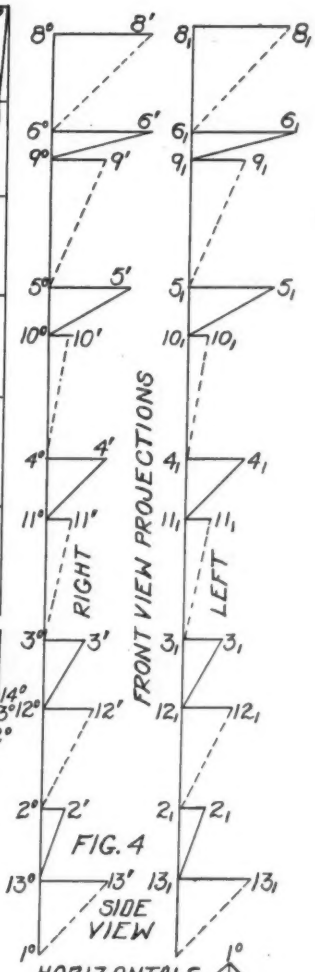


FIG. 4

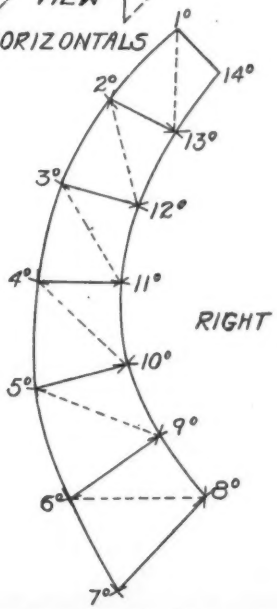
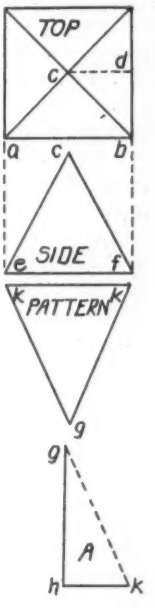


FIG. 2. FIRST STEP IN DRAFTING PATTERN OF ELBOW



SQUARE PYRAMID

FIG. 3

FIG. 4. PRACTICAL USE OF TRIANGULATION

outs. This test is very important as it allows changes and adjustments of the curves, and generally prevents the loss of valuable material and any excess labor costs.

The patterns for the sides of the elbow must be drafted by triangulation, meaning to lay out the surfaces by using a series of three-sided areas or triangles. The side surfaces are twisted and the projections of the construction lines in both the side and front views do not show their true lengths. Therefore, the proper lengths of these construction lines must be determined before the patterns can be laid out. The designer who understands triangulation has the key to the solution of many of the problems in sheet metal work. The principle involved is illustrated in Fig. 3. This illustration shows the top and side views of a square pyramid. It should be noted that the true length of the corner or edge *cb* is not given. In the side view *cf* is the true length of the middle line *cd* of the top view. To get the true length of *cb,* lay off, as shown at A, the line *gh* equal to *cf.* At right angles to *gh,* make *hk* equal to *bd,* or half the length of the base *ab.* Then the hypotenuse *gk* completing the triangle will be the true length of the edge *cb* or *ac.* Use the length *gk* and make *kk* equal to *ab,* and the pattern for the side of the pyramid may be constructed as shown.

Remembering how the true length of the corners of the pyramid was obtained, the true lengths of the construction lines of the elbow will now be determined. A series of triangles must be constructed, using the lengths of the construction lines taken from the front view for the bases, and the altitudes are made equal to the horizontal distance taken from the side view. Then the hypotenuses of these triangles will be the true lengths of the construction lines required. See Fig. 4.

The horizontal distances in the side view are most easily determined by projecting the division points of the two curves vertically on to a horizontal line MN. The lines of the triangles are numbered to correspond with the construction lines in the front and side views. The pattern for the right side is laid out as follows:

The starting line 1° — 14° is made 3 ft. long as required in both the side and front views. With 1° as a center and a radius 1° —13° equal to the true length of the construction line, an arc is struck. Then from 14° as a center and a radius equal to the length 14° — 13° taken from the bottom pattern, an arc is struck intersecting the first arc and thus locating a point on the pattern curve. Also from the point 1° as a center and a radius equal to the arc 1° — 2° from the top pattern, describe an arc, and from the point 13° and a radius equal to the horizontal 1′—13′, describe an arc cutting the first arc. The point of intersection 2° will be a point located on the large curve of the pattern. Use these points that have just been found and proceed in like manner until the entire pattern has been laid out and closed with the line 7° — 8° equal in length to 6 ft., being the length of the opening at the bottom of the elbow.

The pattern for the left side is laid out in a similar manner to that just shown for the right side. Use the construction lines as taken from the left side of the front view and the horizontal distances of the same as taken from the side view, the true lengths of the construction lines to be taken from the diagram of triangles. The arcs used for radii are taken from the top and bottom patterns. After getting the body of the patterns, any additions for laps and flanges should be added on the edges where required. In most cases it is necessary to add a straight piece to the elbows so as to enter the flanged openings. After making the drawings of the patterns, templets are constructed and the accuracy of the drawings tested as explained above. The patterns for the two sides look alike in the drawings, but they are not alike, owing to the fact that the center lines of the two ends of the elbow are offset 12 in. When the patterns are made full size, this difference will be apparent.

It is entirely practical to make the patterns for an elbow of this kind without making any drawings. This is done by constructing a full-sized model and using the covering of this model for the actual patterns. Lay off on the floor of the shop a 3 by 10-ft. rectangle with the long side parallel to the wall. Then on the wall lay off a 3 by 6-ft. rectangle with the long side vertical and with the center line offset 12 in. with the center line of the rectangle on the floor. The height of the rectangle on the wall must be determined by the throat distance required in the elbow. The distance of the rectangle on the floor from the wall must also fill this requirement.

Construct a framework joining these two rectangles with the desired curves. By a cut-and-try process, the structure can be easily made and covered. Heavy paper makes a good covering which can be used for the pattern. As these patterns are the real thing, the stock can be cut from them without fear of spoiling any material. In some cases, this method is the quickest, cheapest and safest one that can be devised.

In order that its students may keep abreast of the new developments in the electrical industry, the New York University has ordered a 75-kw. synchronous motor generator set with automatic switching equipment, from the Westinghouse Electric & Manufacturing Co. This outfit will be arranged so that it can be started or stopped by push button stations located at various points around the building. In addition to its use for exhibition purposes, it will be used as a source of direct current energy for the testing busses.

The synchronous motor is 112 hp., 100 per cent power factor, two-phase, 60-cycle, 220 v., 1200 r.p.m. self-starting synchronous motor, and the generator is a 75-kw., type "SK" direct-current generator, 250-v. d.c., 1200 r.p.m., compound wound, commutating pole, two-wire.

The apparatus is arranged so that on excessive overload, series resistors will be automatically cut into circuit so as to reduce the line voltage to approximately 80 per cent of normal. At the same time, an alarm bell will be rung. The New York University feels that this will afford an opportunity of reducing the load without shutting off the laboratory direct current energy. In case the warning of the alarm bell is disregarded, the station will shut down in the time interval necessary to operate the grid thermostats.

While superheat to 750 deg. may be used in turbines, the limit for poppet-valve engines is best placed at 650 deg. and for Corliss engines at 500 deg. In using superheated steam with Corliss or flat valves, it is necessary to have a pure mineral oil forced to the working surfaces.

Diesel Engine Practice---I

A Discussion of the Diesel Oil Engine; Its Construction, Operation and Lubrication. By A. H. Pritchard*

DIESEL ENGINES adapted for use as prime movers in power plants are built in various sizes from 100 to about 3000 hp. The principal American builders of this type of engine number less than ten. While there are units in the United States larger than 3000 hp., they are unusual and are the exception rather than the rule. This factor of power required has therefore limited the possibilities of the universal use of the Diesel engine, although in addition to this, availability of fuel has also been a factor. It is due to the latter factor that there are more Diesel engine installations in the middle and western part of the United States than in the East; fuel requirements for this engine are more easily fulfilled from the immense production of the mid-continent oil fields.

The Diesel engine is often confused with other types of oil engines such as semi-Diesel, super-Diesel, surface ignition, solid injection, hot bulb, etc. These types vary from a low compression with a hot bulb or plate type to a compression as high as the true Diesel with some method of mechanically atomizing the fuel.

In the true Diesel engine ignition is brought about by the injection of fuel, in a very finely atomized form, into the highly heated air in the cylinder; the air being at such a temperature due to rapid compression to about 480 lb. per sq. in.

The same principle is used with all kinds of oil engines, except that in all but one instance they use lower compression pressures varying from 100 lb. to 350 lb. With the lower compression engine, the ignition of the fuel is brought about by a jet of fuel being sprayed by mechanical pump pressure into a hot ball, bowl or against a hot plate.

As the compression pressure is raised to 250 lb. or 350 lb., some builders vary the design of a hot plate or ball to a heavy mass of metal in the head which in itself is not water cooled but is adjacent to a water jacketed part so that its temperature is fairly constant. This heated part does not ignite the fuel. There is, however, a very rapid transfer of heat from the heated part to the heat of compression, the total of which is sufficient to fire the fuel.

It will, therefore, be readily understood that we must have air in our cylinder uncontaminated by burned gases of a previous charge, and have it compressed to a high pressure sufficient to raise its temperature high enough to fire the charge.

One of the factors, therefore, which make for clean burning of the fuel is a constant temperature not too high and not too low of the compressed charge of air. Another factor is the perfect atomization of the fuel. This latter condition is more nearly approached with the use of high pressure air than with any nozzle designed with pump injection commonly spoken of as "solid injection." While there is one successful builder of this type of engine, there is still much opportunity for development in this line.

There is one type of oil engine that uses full Diesel compression to 480 lb. or thereabout. The fuel feeds by gravity to a cup in the combustion chamber in which the fuel is raised to such a temperature as to cause its vaporizing, which vapor pressure causes a spraying of the fuel through small drilled holes and burning results from this spray coming into contact with the highly heated compressed air in the combustion chamber.

Figure 1 shows the pressure range for various types of oil engines.

Types of Construction

Diesel engines are built both horizontal and vertical, the vertical being the type more commonly used. One builder manufactures engines of two-stroke cycle only; another uses both four and two-stroke cycle. This latter builder uses the four-stroke cycle type for engines varying from 30 hp. to 125 hp. per cylinder. For larger sizes he uses the two-stroke cycle. There are no two-stroke cycle horizontal Diesel engines built in this country today. The horizontal four-stroke cycle Diesel engines range from about 40 to 200 hp. per cylinder, each engine using two, three or four cylinders.

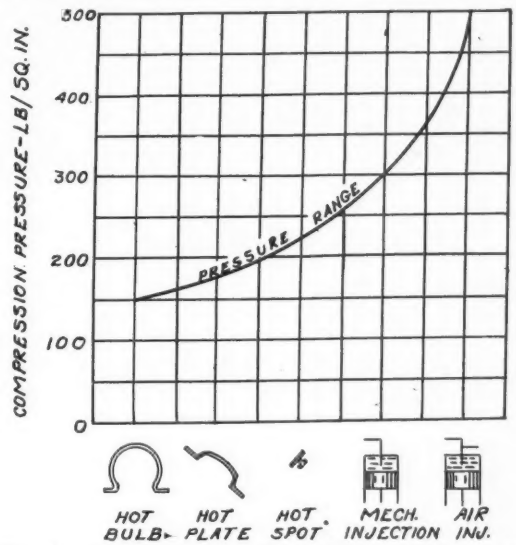


FIG. 1. PRESSURE RANGE FOR VARIOUS TYPES OF OIL ENGINES

In the vertical types there are two general designs in use, box frame and "A" frame. In the A frame type, each cylinder is cast with the frame shaped somewhat like the capital letter "A," hence its name. This type permits easy access to each main bearing and also permits of economical production methods in foundry and machine shop.

In the box frame type, the crankcase of the entire engine is enclosed in a single "box-shaped casting," on which are mounted the cylinders.

All Diesel engine cylinders are of a two-casting design. A liner forms the cylinder wall and its insertion in another casting with suitable spaces between liner and outer casting form the water jacket. This also permits of economical renewal by the simple removal of the old and replacement of a new liner.

* Chief Engineer Western Branches, Vacuum Oil Co.

Cylinder head design is most important, principally from the standpoint of equal distribution of the cooling water. The cylinder head is subjected to varying temperatures in its different parts. In the four-stroke cycle engine, the air and exhaust valve are both located in the head, one on each side of the center point. Here we have on one side air entering or passing through the valve at atmospheric temperature, while through the other valve on the opposite side we have the flow of exhaust gases at about 750 deg. F. In addition to this, the inner surface is exposed to the maximum temperature of the combustion chamber which is estimated at from 2500 deg. F. to 3000 deg. F.

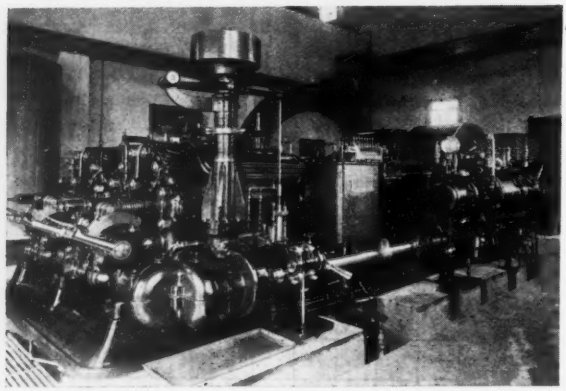


FIG. 2. TYPICAL TWO-CYLINDER, FOUR-STROKE CYCLE, HORIZONTAL DIESEL ENGINE

Both two and four-stroke cycle Diesel engines have a camshaft. Generally it is driven by two sets of worm gears from the main crankshaft. This same shaft also drives the governor. These worm gears have given some trouble in the past which has been attributed to incorrect lubrication. This has in only a very rare instance been the real difficulty. Suggestion is made that the alinement be checked carefully, also that an accurate measurement of the gears themselves may indicate improper gear cutting. An ample supply of the same lubricant that is used on the bearings will give correct lubrication of these gears.

Cooling of Cylinders

THE COOLING of the cylinders and cylinder heads should be given every attention. The efficiency of the engine can be increased by keeping the temperature of the cooling water discharge at a high degree, about 150 deg. F. to 170 deg. F. There are limits to which this can be carried in that the cooling water used may throw down solids at low temperatures, which solids will collect in the form of scale coating the cylinder walls and with such insulation really defeat the purpose of cooling, which is, of course, the maintaining of a temperature of the cast iron at a point where it will not warp or crack. Overheating also results in piston seizures. On the other hand, the air compressor cylinders and intercoolers should be run as cold as the temperature of the cooling water permits. The air compressor operates at its highest efficiency at low temperatures.

Sometimes muddy water is used for cooling and mud and dirt will collect in the bottom of the cylinder jackets. In this way, the cooling efficiency is interfered with. By tapping the bottom of cylinder jackets and introducing a temporary connection of compressed air sufficient agitation to wash these spaces thoroughly will be provided. The frequency with which this should be done will depend on the amount of contamination carried by the water and how quickly it collects.

Another disadvantage of running too low a temperature of cooling water is that with a sudden increase in load there has occurred the rapid expansion of the piston without the proportional increase in cylinder size due to the fact that the coolant is too cold and will not warm up as quickly. The result has been piston seizures when this combination of conditions occurs.

It is very important in multi-cylinder engines that the main bearings be in perfect alinement. If one of these bearings works a little low, the result will be a constant "flexing" of the main shaft back and forth, finally resulting in breaking of the shaft.

Analyzing the Exhaust

THE OPERATOR should carefully watch his exhaust. If this is not clear, he does not have perfect combustion. If the color is black, it may be unsuitable fuel. An overloaded or underloaded condition will also give the same color, black. This can be corrected by raising the blast pressure for higher loads and lowering the blast pressure for lower loads. If the color is tending toward

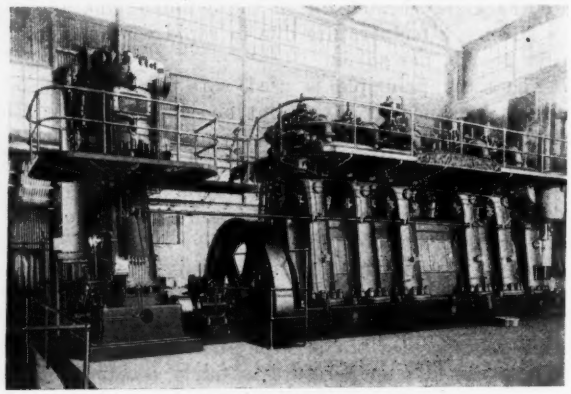


FIG. 3. VIEW OF VERTICAL TWO-STROKE CYCLE DIESEL ENGINE

a gray or almost steam color, there may be a water leak into the cylinder or as is usually the case, this color indicates the burning of some lubricating oil in the combustion chamber, which in turn means overfeeding at some point.

In multi-cylinder engines, the installation of a pyrometer in each exhaust line will permit the quick checking of the work done by each cylinder. If each of these were run to a recording chart, there would be a real record of what each cylinder was doing. It will prevent the "laying down" of any one cylinder and the overloading of the others. Also in case of such "laying down," the cylinder operating incorrectly can be immediately identified without any trouble.

The Air Compressor

THE AIR compressor has been the "bugaboo" of all operators and, to a degree, necessarily so. It is doing work out of the ordinary. We don't find many com-

pressors pumping air to 1000 lb. in a day's travel; that is, aside from the Diesel engine installations, so the moment such a condition is mentioned the operator becomes doubtful and weak-hearted as he has had no experience with such a machine. But the hazard is purely mental. There is no *real* problem today in the right handling of these accessories. Just observe the same rules as with any compressor working on 100-lb. pressure.

The original three-stage air compressor was built into a single piston with the first stage built along the lines of trunk piston and located at the bottom or outer end, above this the second stage smaller in diameter and above this the third stage.

This design was not successful, as it was found that oil vapors would be drawn into the first stage on its suction stroke, which vapors provided excess oil and a positive interference with correct operation.

This design was changed to the type shown in Fig. 4 commonly used today. That is with the second stage at the bottom or outer end the first stage above this and

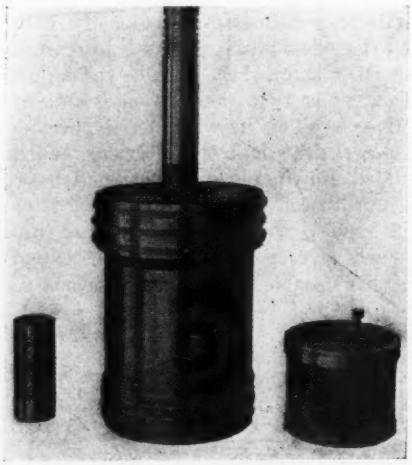


FIG. 4. NEW TYPE OF AIR COMPRESSOR PISTON

the third stage at the top. In this way, with a pressure going to the bottom piston from the intercooler between the first and second stage there was no possibility of drawing in crankcase vapors.

As to operation first and foremost, use as small an amount of oil as you can and still have lubrication of the air compressor cylinders. Here again the minimum amount is only found by running with a certain rate of feed and then an inspection. There are only small surfaces and cylinders to lubricate, however, and a very small quantity will do. In fact, it is difficult to find a lubricator that is reliable that will feed the very small quantity needed. Only recently, a prominent lubricator manufacturer made an improvement in his design that permits the positive feeding of small quantities of air compressor oil.

Second, be sure the valves are in good working condition; thus there are no deposits of gum or carbon. If valves are not working perfectly, better shut down and correct them, as serious trouble may result from highly heated, highly compressed air leaking back into the cylinder, and this repeated 180 to 225 times a minute rapidly builds up the temperature of the air to the danger point.

Third, run the coldest water that can be secured on the air compressor cylinders and intercooler coils. Take no stock in the statement that the compressor should run warm. It is all wrong.

Fourth, drain the separators in the intercooler coils at regular intervals. This should not be done by a hit or miss policy but at a regular time during the day and night. These should be blown, the reason being that these separators collect the moisture and some oil. If they fill up and moisture is carried on into the next stage, it will wash the lubricant off the cylinder walls, the cylinder and piston will wear rapidly or else more lubricant than is necessary is fed and carbon troubles occur. If considerable moisture is found, it would be advisable to drain separators more often. If moisture is carried over into the bottles or storage tanks, these should also be blown down regularly.

Valve Disc Comes Off

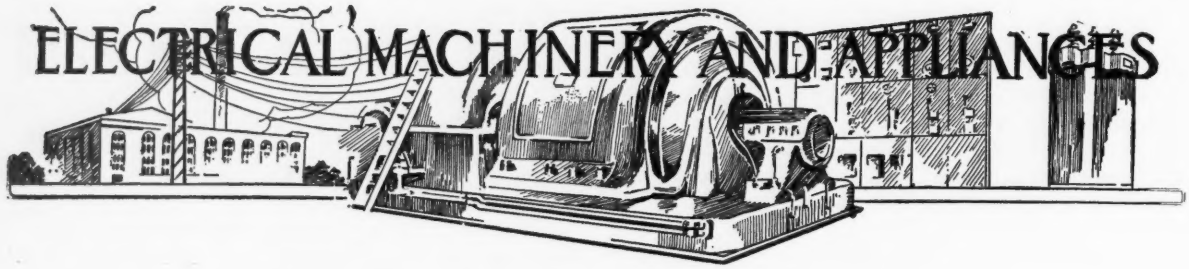
By John C. Kahl

IN A CERTAIN manufacturing plant sometime ago a small 8 by 10-in. slide-valve engine was belted to a 5-kw. generator used for the lighting of the plant. One morning while things were apparently moving along nicely this lighting engine slowly came to a complete stop without any special reason. Word was telephoned the master mechanic who gave instructions to let things stand until he arrived. Upon his arrival the steam chest cover was removed and the valve taken out, which made visible a crease on the metal across the exhaust port and which later proved nothing more than a hair line in the mold.

Upon the assumption that this was a crack in the cylinder wall, a new cylinder was ordered without further examination or investigation for further trouble. The new cylinder came and was placed on the engine, the valve placed in position and set. The engine was started and ran perhaps two minutes when it again came to a complete stop. The throttle was closed and after a while the engine was started again with the same result. An observer from a neighboring plant suggested that the bonnet be removed from a valve in the exhaust pipe just beneath the engine cylinder and an effort be made to ascertain what was in the exhaust line. This was done, with the result that it was found that the disc was off the stem. The disc was again secured to the stem and replaced, the bonnet tightened and the engine started. It ran just as well as it ever did.

When the engine was giving its trouble, the exhaust steam from the cylinder evidently caused the loose valve disc to seat and after the pressure would diminish in the cylinder due to condensation and leakage through stuffing-box, the back pressure in the exhaust line evidently lifted the disc from its seat.

IT IS the opinion of many Chilean mining experts that it will not only be possible in the near future to get good coal from the existing yields in Concepcion, but also in Bio Bio, Valdivia and Llanquihue, while coal is also believed to exist in the island of Chile. It is considered that there is a good opening for the employment of British and other foreign capital in the development of the Chilean coal fields.—Compressed Air.



Switchboards for Industrial Plants

STRUCTURAL FEATURES, METHODS OF CONTROL, INSTRUMENTS AND PROTECTIVE DEVICES. BY VICTOR H. TODD

WHEN electricity is generated and utilized for light and power in industrial plants, some means must be provided to connect and disconnect the generators from the load system; means must be provided to disconnect certain loads or portions of the plant as the occasion demands and instruments must be provided to indicate the correct functioning of all apparatus and measure the various amounts of energy generated, transformed and consumed. Instead of supplying switches and instruments located in a haphazard manner in the immediate vicinity of the various pieces of apparatus, it is customary to locate all switches and instruments at one point on a "switchboard." The switchboard may consist of anything from a single panel of only a few square feet with a single switch and meter, up to a board with dozens of large panels each with its full equipment of switches, and instruments.

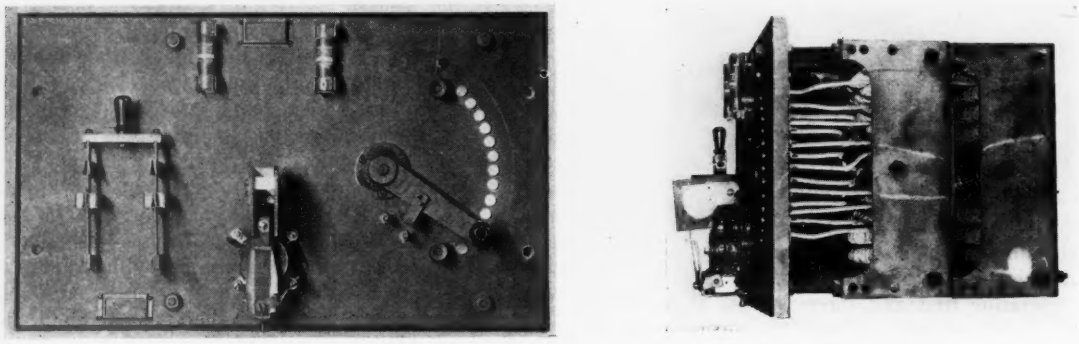


FIG. 1. SMALL CHARGING PANEL, FRONT AND SIDE VIEWS

The rear of the board is frequently as important as the front, especially in the smaller capacities and lower voltages, as here are often located the fuses, temporary sectionalizing or testing switches as well as the busses and feeders. Much damage can be done at the rear of the board, both personal and material, as the high tension is often brought exposed to the rear of the board while it would not be tolerated on the front. Short circuits behind the board are especially severe, as they are often not only unprotected, but the bus-bar is almost the point of least resistance in the system, not having even feeder resistance to limit the short circuit current.

SELECTING A SWITCHBOARD

THERE ARE several factors affecting the selection of a switchboard. The first division is into standard and special. The large switchboard manufacturers of the country have thoroughly investigated and catalogued the main uses of electrical apparatus in the industrial concern and have standardized on certain combinations which could be used in many identical installations in all parts of the country. Obviously, this elimination of special drawings, estimates, and constructions has reduced the price of standard products to reasonable costs.

On the other hand, there may be special cases where the designer finds that there is no standard product which will exactly fit in with his requirements. The result is special drawings, specifications, contracts, long delivery dates and complicated constructions which soon eat up even a liberal appropriation for a given installation. The choice, then, is obvious; use standardized equipment whenever possible even to the extent of sacrificing some dispensable features in the special equipment.

The next set of factors controlling the selection of a suitable switchboard are (1) first cost; (2) continuity of service; (3) safety to life and property; (4) space available and (5) current and voltage capacity. In many cases, the first cost is the all important factor. This is especially true of the small firm with but little spare capital. Small first cost apparatus can be purchased which will give satisfactory service especially if under competent supervision and if an occasional interruption is not objectionable. In the larger plant employing many thousands of workmen and often running day and night, a breakdown or even a moderately long service interruption may be disastrous; even a small delay may cause confusion and danger if it should extinguish the lights in a large isolated building. To avoid this, nothing but the latest and most perfect type of

apparatus, switchboard and protective equipment should be employed. Some firms even go to the extent of duplicating every important unit in the system and providing spare feeders and switching equipment often automatically controlled to reduce an interruption to an absolute minimum.

Space available often limits the size of a board and may cause the selection of a remote control board as will be described later. Voltage and current capacity are of course important factors, the voltage of the system determining the insulation and the class of apparatus which may be placed on the switchboard and the current capacity determining the size of the bus-bars and connections.

Classes of Switchboards

Classed as to method of operation, switchboards may be divided into direct control boards, manual remote control and electrical remote control. The first class is used almost universally for small outfits such as small d.c. manufacturing plants, hotels, public buildings and the like. The limit of a direct-control switchboard is usually about 800 amp. and up to 2500 v. at a capacity of 3000 kv.a.

Above this capacity, if space permits, the manual remote control board is used. In this, the switches are all located at the rear, or under, or in a switch gallery above the switchboard while the switch handles and instruments alone are on the board. When, however, the switches and rheostats are operated through rods or chains over 50 ft. in length, the manual labor becomes excessive in overcoming the friction between the handle and switch, and resort is made to the electrical remote control switchboard. This represents the highest advance of the art, but is seldom encountered in the average industrial plant because of its great cost and complicate construction.

Material of Switchboards

The first switchboards were made of hard wood, but were unsatisfactory, due to the shrinking and consequent alining of the switches. Wood is also not at all suitable for high voltages, as its absorption of moisture makes it a partial conductor which introduces an undesirable fire risk. For modern boards up to about 750 v. ordinary slate is the preferred material. This is generally painted a dull velvety black, giving a pleasing appearance; it is easy to refinish and does not mar.

On higher voltages, it is customary to use a good grade of marble. This may be painted black to match portions of the low tension panels or it may be polished and when supplied with natural-copper-finished instruments, makes a truly handsome appearance. This type of board is often used in large public buildings, especially where the engine room is open to outsiders.

Construction

Material for electrical switchboards may be mounted either by angle iron or tubular framework. For small isolated panels, either may be used to advantage. For the switchboard which is completely designed and no provision made for future expansion, the tubular framework is employed; but for the cheap board where additions may be made later, the angle iron framework may be used to advantage. Another good point about angle iron framework is that the panels may be wired completely and shipped without dismantling. When received, the sections need be only bolted together, and the proper connections made between sections. The grounding of framework is an important detail. All framework of boards above 150 v. should be securely grounded, possible exceptions being a grounded trolley system or a series lighting circuit. In this case, sufficient rubber mats should be employed to guard the attendant effectively from possible contact or shock.

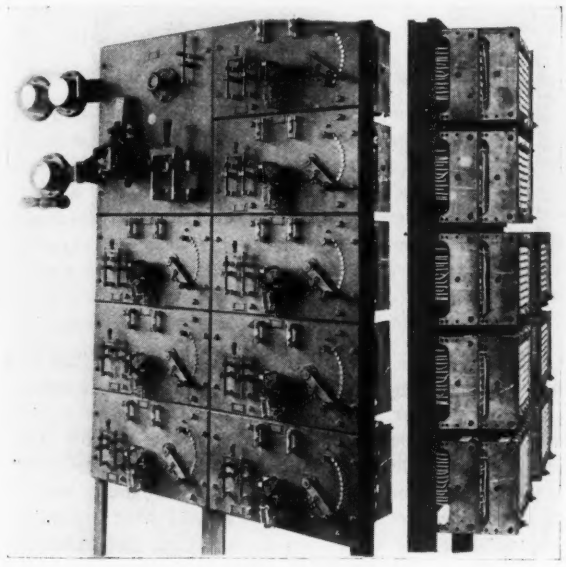


FIG. 2. TYPICAL CHARGING PANEL

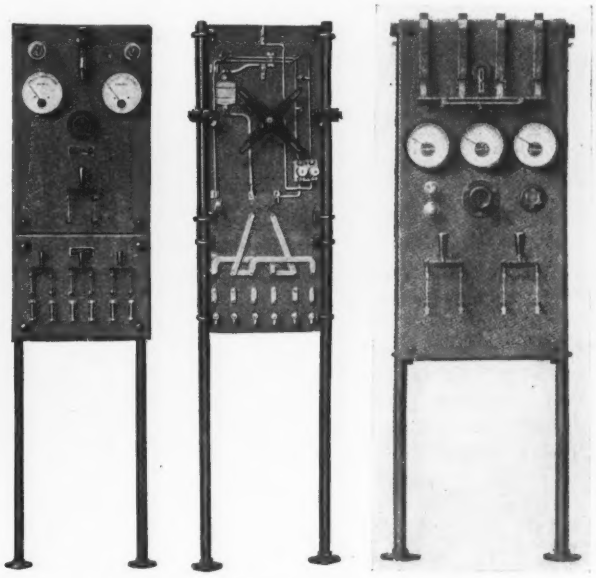


FIG. 3. FRONT AND BACK VIEWS OF SMALL COMPLETE SWITCHBOARD FIG. 4. THREE-WIRE SWITCHBOARD PANEL

Typical Boards

Perhaps the simplest illustration of a switchboard is the small charging panel shown in Fig. 1. This is frequently employed in garages or other places where

batteries are charged. An important rule of the National Electric Code is that such panels, when located in a place where gasoline is handled, must have all spark producing devices mounted 4 ft. above the floor. If lower than 4 ft., the charging panel must be surrounded by a vapor-proof enclosure, or the panel located in a separate room provided for this purpose.

This simple panel contains the main line fuses, the main switch, automatic circuit-breaker, and rheostat for varying the charging current.

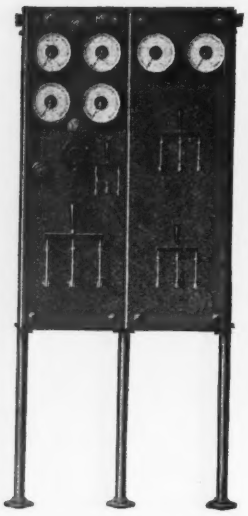


FIG. 5. SIMPLE THREE-PHASE SWITCHBOARD

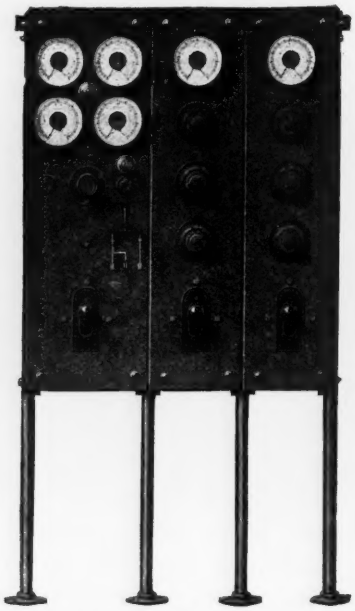


FIG. 7. SWITCHBOARD WITH OIL SWITCHES FOR HIGHER VOLTAGES

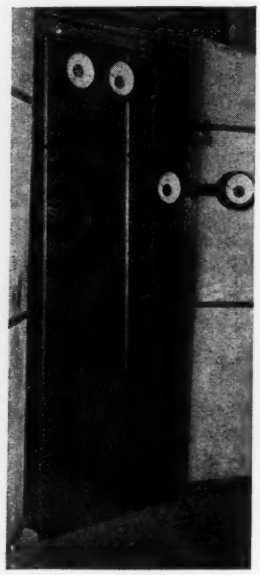


FIG. 8. SYNCHRONOUS MOTOR AND CONVERTER PANELS

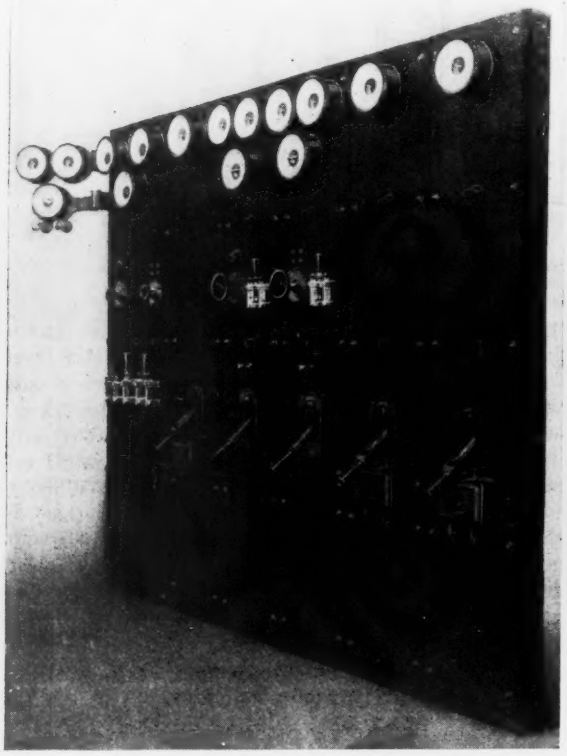


FIG. 6. TYPICAL SWITCHBOARD FOR SEVERAL A.C. GENERATORS

Where a more elaborate board is required, the one shown in Fig. 2 may be employed. This is built mostly of sections similar to Fig. 1 with the addition of the panel in the upper left-hand side of the board. This panel contains the main circuit breaker provided with overload and reverse current releases; the main switch and the field rheostat are also mounted here while the generator ammeter and voltmeter, and the charging

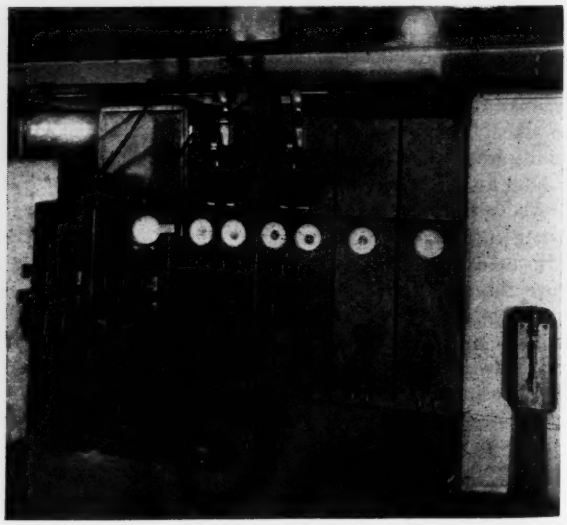


FIG. 9. FRONT VIEW OF SYNCHRONOUS CONVERTER SWITCHBOARD

ammeter and two ground detection lamps are mounted on swinging brackets at the side of the switchboard.

Two-Wire D.C. Generator and Feeder Panels

Figure 3 illustrates a typical panel for a small complete switchboard. The upper panel contains the main switch, automatic circuit breaker for the protection of the generator, the generator field rheostat, the ammeter and the voltmeter. As will be seen from the rear view, the lower panel has the clips of the switches all connected in parallel to form a bus. The three switches supply three independent feeders running to various parts of the plant.

Although complete in itself, this panel may be supplied with the main switch in the form of a double-pole double-throw instead of a double-pole single-throw switch, so if the generator fails, the total load may be thrown to another circuit by throwing over the switch.

These isolated panels are generally used on two-wire circuits up to 250 v. In current capacity they are limited to 400 amp. for the generator; 125 amp. for a three-feeder panel; 250 for a two-feeder, and 100 amp. for a four-feeder panel.

Three-Wire Panels

The economic use of copper as employed in the three-wire system is well known, and consequently we find many three-wire systems employing a panel similar to Fig. 4. This board mounts a four-pole circuit breaker to disconnect both generators in case of severe unbalancing or other abnormalities; ammeters for both sides of the system; a voltmeter field rheostat and main switches. If necessary, they may be provided with equalizer connections to enable two or more panels and generators to supply the system.

A.C. Generator Panels

The a.c. panels differ from the d.c. panels in that they must also mount the exciter equipment or have it mounted on a separate panel. Due to the inherent inefficiency of the single-phase generator, it is seldom employed. Most a.c. circuits are either two-phase or three-phase and a simple switchboard takes the form of Fig. 5, where the left-hand panel contains a main three-phase knife switch, the field discharge switch, the field rheostat, the a.c. voltmeters, with plug switches enabling them to read the voltage on any phase, and three ammeters, one in each phase. The panel at the right is supplying two feeders with an ammeter in each phase. If considered essential, this panel may also be provided with ammeter switches by which current in any phase may be easily determined.

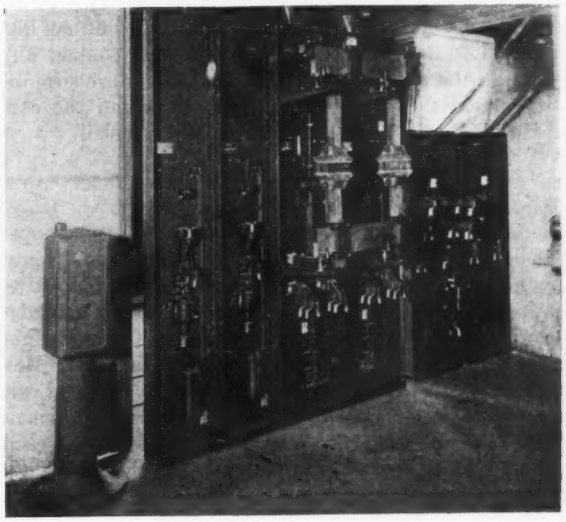


FIG. 10. REAR VIEW OF SWITCHBOARD SHOWN IN FIG. 9

When several generator panels are used with several parallel generators, then the board may assume the appearance of Fig. 6, where the equipment common to all machines is shown on the swinging end bracket. Only one voltmeter is used to indicate the bus voltage; one voltmeter is used to indicate the voltage of a machine being synchronized and the synchronoscope indicates synchronism. The object of putting these instruments at right angles to the board is so that they may be easily seen from any generator panel at the time of synchronizing. Below the synchronoscope are shown two lamps which are used as a check on the correct functioning of the synchronoscopes.

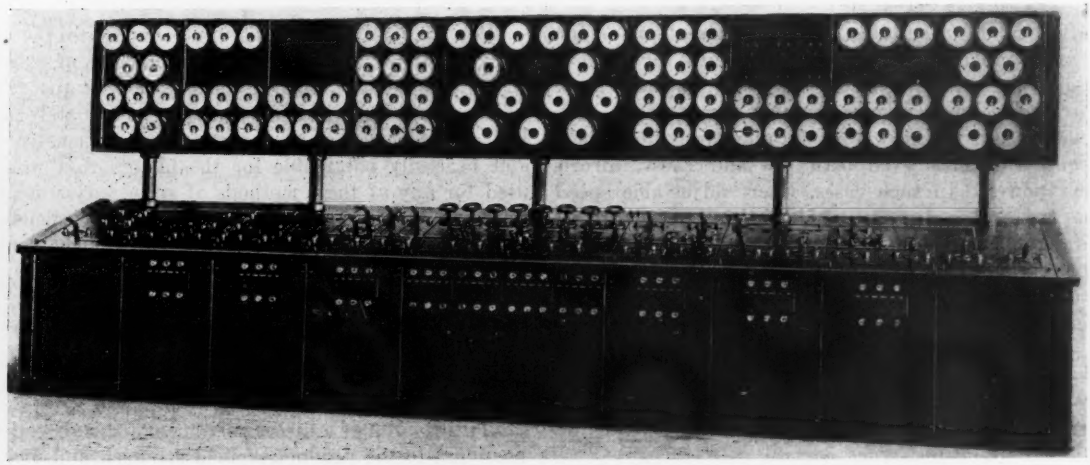


FIG. 11. REMOTE CONTROL INSTRUMENT BOARD AND DESK

Higher Voltage Panels

When the voltage used is above 750 v., it is no longer safe to run to bare knife switches, located on the front of the panel. Not only might accidental contact prove fatal, but the breaking of even a small current at potentials of 1000 or 2000 v. might cause a vicious arc of great intensity. The board now employs oil switches located on the rear of the panel, with only the handles showing as in Fig. 7. This contains the necessary ammeters, voltmeter, field-rheostat, and switch, but no high potential is found accessible to accidental contact anywhere on the panel. Even the instruments are supplied with potential and current transformers and the cases and switchboard framework securely grounded.

Automatic Protection

As a rule, standard panels are not usually provided with automatic protection for either main circuits or field circuits. The inherent reactance of an alternating current generator enables it to withstand a heavy overload for a short time and in fact some generators may be short circuited without damage. However, if desired, standard panels may be obtained with an automatic oil switch. The advantages of automatic protection are that the breaker is quickly and easily closed after opening; it cannot be held closed while an overload exists, and it eliminates the trouble and expense of replacing fuses.

Synchronous Motor and Converter Panels

Synchronous motor panels must have the instruments necessary for starting and regulating the field. A typical panel is shown in Fig. 8. An a.c. ammeter for the armature circuit and a d.c. ammeter for the field circuit are quite essential, and power or reactive factor meters may be included.

The synchronous converter switchboards are still more complicated as shown in Fig. 9, while a rear view is shown in Fig. 10.

Electrical Remote Control Switchboards

It is usually a case of extreme space economy that demands the electrical remote control system in the average industrial concern power plant. The circuit breakers may now be located at any convenient point and are arranged to be electrically closed or opened. The board and desk may appear as in Fig. 11. The instruments are mounted as previously to indicate the current, voltage, power factor, or synchronism, but the closing or opening of the switches or breakers is done by merely pushing buttons or turning small handles on the desk. Signal lamps are employed to indicate the condition of the breaker, that is, a red lamp lights when the breaker closes and a green one lights when it opens. Even the field rheostats are electrically controlled, the operator holding in a "raise" or "lower" button until the desired result is obtained.

Specifications for a Switchboard

When the industrial concern contemplates the purchase of a new or additional switchboard, there are such a maze of details to be specified, that unless some approved form is used, there will almost invariably be details missed which will cause inconvenience and serious delay. The large manufacturers maintain efficient engineers who give free advice on the design of a board and will gladly furnish specification blanks covering every detail of the board.

Efficiency of Adjustable Speed Motors

Discussion of Causes of Changes in Performance of Machines. By R. W. Owens

CHOICE OF a suitable adjustable speed motor for any application depends upon so many factors that a proper selection can be made only by comparison of all these factors. In power plants, for example, both alternating and direct-current supplies are often available and sometimes even both 115 and 230-v. direct-current power. In such cases, where adjustable speed motors having speed ranges of about 2 to 1, are required for driving small pumps, blowers, stokers or similar equipment, any one of the following schemes of speed control may be used:

Direct-Current Motors—
1—Shunt field control
2—Armature resistance control
3—Armature voltage control

Alternating-Current Motors—
1—Secondary resistance control
2—Pole change.

There are other methods of obtaining adjustable speed, such as the single-phase commutator motor and the induction motor with different applied frequencies, which are suitable for certain applications. Only the schemes listed above, which are more common and more generally applicable, will be considered here.

For applications of this type, and with the possibility of choosing any one of these methods of obtaining an adjustable speed drive, the question of the relative efficiency of the different methods immediately arises. Data on efficiency at the normal speed is usually available or easily obtainable for the motors that would be used for any of these methods of speed adjustment. It is impossible to give data of the effect on efficiency of speed increase or reduction of speed, which would be applicable to motors of all makes. It is possible, however, to arrive at a few simple rules for estimating with fair accuracy the efficiency for any speed change on any motor.

Direct-Current Motors With Shunt Field Control

The torque of a direct-current motor is directly proportional to the product of field strength and armature current. The speed of a direct-current motor is inversely proportional to the field strength. Therefore, if the speed of a motor is increased by weakening the field, the armature current must increase in direct proportion to the speed in order to maintain constant torque. Horsepower is directly proportional to the product of the torque and speed, so that the horsepower output of such

a motor, with torque remaining constant, increases directly with the speed. Assume a 40-hp., 575 to 1150-r.p.m. shunt wound motor driving a load which requires 40 hp. at 1150 r.p.m., the load being of such a nature that the torque required to drive it is the same at all speeds. To reduce the speed of this motor to 575 r.p.m. requires that the field strength be doubled. With this doubled field strength only one half the armature current will be required to develop the same torque at 575 r.p.m. as was developed at 1150 r.p.m. From the fact that the same torque is developed at one-half speed, it is apparent that the horsepower output at 575 r.p.m. is 20 hp. If the efficiency curves of this motor were the same at all speeds, the efficiency for any speed reduction with constant torque load could be obtained by reading efficiency at a load obtained by reducing the load at maximum speed in direct proportion to the reduction of speed.

For a direct-current motor with speed adjustment by shunt field control, the efficiency curves at different speeds are not quite identical, because part of the losses in the motor vary with the speed. The armature, commutating field, and series field I^2R losses obviously are independent of the speed, but friction and windage losses, iron loss and shunt field I^2R loss change with speed. The friction losses increase about directly with the speed, and windage losses increase roughly as the second power of the speed. The shunt field I^2R loss decreases as the speed increases. Its rate of decrease depends upon the degree of saturation of the iron which in turn, changes as the speed increases, so that as higher speeds are reached this loss decreases directly as the speed increases.

The change of iron loss with change of speed is complicated by the effect of field distortion, so that, for one design of motor, it may decrease with increasing speed while for another design it may increase. The general tendency is the latter, but for moderate ranges of speed adjustment, that is, ratio of speeds up to about 2 to 1, the increase of iron loss is quite small. With friction, windage and iron losses increasing and shunt field loss decreasing with increasing speed, it is apparent that the nature of the change in the sum of these losses depends upon their relative magnitudes. For the usual types of commercial motors with, say, 2 to 1 speed range, the sum of these losses increases slightly with increased speed, so that for any load the efficiency at the high speed is lower than the efficiency at the low speed. This change in efficiency is relatively small, however. Figure 1 shows calculated efficiency curves for a 40-hp., 575 to 1150-r.p.m. motor. These curves are typical for this class of motors and will serve as a guide for estimating efficiency when speed is changed by varying the shunt field strength, the efficiency curve at one speed being known.

Direct-Current Motor With Armature Resistance Control

If the field strength of a direct-current motor is kept constant and the voltage applied to the armature is varied, the speed of the motor will change very nearly in proportion to the change of applied voltage. The speed of a motor may then be adjusted by applying different voltages to the armature or, as in the more usual procedure, since only one voltage is generally available, by inserting resistance in series with the armature so that part of the line voltage is lost in IR drop in the resistance and the remainder is available at the armature terminals. Torque being proportional to field strength and armature current, if the field strength remains constant and speed is changed by armature control, the armature current will change directly as the torque changes. For a constant torque load, therefore, the armature current will remain constant for all speeds. For such a load, if speed is changed by inserting resistance in series with the armature, the total applied voltage is constant, the current is constant, therefore the total motor input is constant. Output, however, being the product of torque and speed, decreases directly with speed. The efficiency of a motor driving a constant torque load with this type of control, therefore, decreases in direct proportion to the decrease of speed. This rule also applies when torque changes with speed. Suppose that the torque decreases as the speed decreases, then the input decreases with the decrease in torque while the output decreases with the decrease in torque

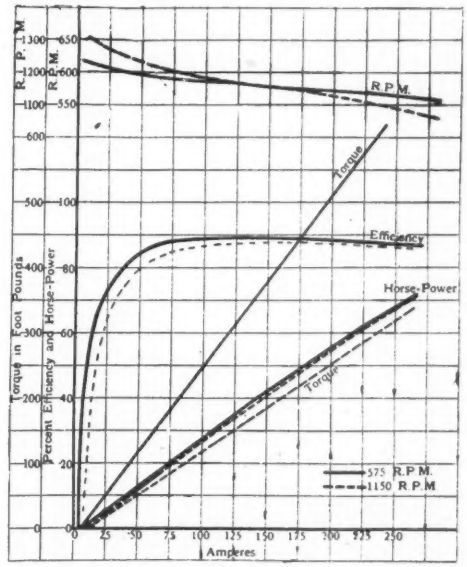


FIG. 1. TYPICAL CURVES FOR MOTORS WHEN SPEED IS CHANGED BY VARYING THE SHUNT FIELD

and also with decrease in speed. The ratio of output to input, or efficiency, then still decreases directly as the speed, or the efficiency, when developing any torque at reduced speed, is equal to the efficiency when developing the same torque at full armature voltage times the ratio of reduced speed to the speed at full armature voltage.

In the foregoing discussion the effect of friction, windage and iron losses has been neglected; however, if these losses vary directly as the speed, the rule given will still be exact. In a motor whose speed is adjusted by armature resistance, these losses do vary almost directly as the speed. Table I gives calculated losses for 40-hp., 1150 r.p.m. shunt, series and compound wound motors with speed reduced to 575 r.p.m. for a constant torque load and also for a load where torque changes as the second power of the speed. For this table a motor has been assumed with relatively large friction, windage and iron losses, yet it will be observed that the rule holds closely, especially where the speed reduction is approximately 50 per cent.

Direct-Current Motor With Armature Voltage Control

Where means are available for changing the applied voltage without inserting resistance in series with the armature, the speed decreases nearly in proportion to the decrease in applied voltage. The input to the motor then decreases practically with the decrease in speed. Since the output decreases with speed, the efficiency with this type of control for a given torque at any speed reduction is the same as the efficiency for that torque at full speed or the efficiency for moderate speed ranges is practically independent of the speed.

The conclusion reached in the preceding paragraph was based on the assumption that the speed of a motor decreases directly with the decrease of voltage applied to the armature. Actually the speed decreases directly with the decrease of counter-electromotive-force. Analysis of the difference between the assumed conditions and the actual conditions shows that it was assumed that the variable I^2R losses decrease with speed while they actually remain constant for a given torque. Also the effect of iron losses, friction and windage and shunt field losses was neglected. Table II shows calculated efficiencies for the same motors as in Table I except that the speed is adjusted by changing the voltage applied to the armature. Table II shows that, for a given torque, the efficiency decreases somewhat as the speed is decreased by armature voltage control.

TABLE I. EFFECT OF SPEED REDUCTION BY ARMATURE RESISTANCE

	Shunt Motor				Compound Motor				Series Motor			
Torque—lb. ft.	183	183	46	46	183	183	46	46	183	183	46	46
R. p. m.	1150	575	1160	575	1150	575	1300	575	1150	575	1770	575
Hp.	40	20	10.2	5.04	40	20	11.4	5.04	40	20	15.5	5.04
Amperes	145	143.5	42.1	40.5	145	143.5	46.8	44.9	144.9	143.5	64.5	62.5
F. & W. losses—watts	640	270	640	270	640	270	770	270	640	270	1230	270
Iron loss—watts	1040	410	880	320	1040	410	1060	320	1040	410	1600	340
Shunt loss—watts	380	380	380	380	230	230	230	230	....	....	....	....
I^2R losses—watts	1450	17 020	170	4590	1600	17 170	230	5750	1810	17 400	430	10 000
Total losses—watts	3510	18 080	2070	5560	3510	18 080	2290	6570	3490	18 080	3260	10 610
Input—watts	33 350	33 000	9680	9320	33 350	33 000	10 790	10 330	33 330	33 000	14 820	14 370
Output—watts	29 840	14 920	7610	3760	29 840	14 920	8500	3760	29 840	14 920	11 560	3760
Efficiency—per cent	89.5	45.1	78.6	40.3	89.5	45.1	78.8	36.4	89.6	45.1	77.9	26.2
Estimated efficiency	....	44.8	....	39	....	44.8	....	35	....	44.8	....	25.8

TABLE II. EFFECT OF SPEED REDUCTION BY CHANGE OF VOLTAGE

	Shunt Motor				Compound Motor				Series Motor			
Torque—lb. ft.	183	183	46	46	183	183	46	46	183	183	46	46
R. p. m.	1150	575	1160	575	1150	575	1300	575	1150	575	1770	575
Hp.	40	20	10.2	5.04	40	20	11.4	5.04	40	20	15.5	5.04
Armature amperes	143.4	141.9	40.5	38.9	144	142.5	45.8	43.9	144.9	143.5	64.5	62.5
Armature Volts	230	120.1	230	116.2	230	120.5	230	103.8	230	121.1	230	76.5
F. & W. losses—watts	640	270	640	270	640	270	770	270	640	270	1230	270
Iron loss—watts	1040	410	880	320	1040	410	1060	320	1040	410	1600	340
Shunt loss—watts	380	380	380	380	230	230	230	230	....	....	....	....
I^2R losses—watts	1450	1430	170	160	1600	1580	230	210	1810	1770	430	410
Total losses—watts	3510	2490	2070	1130	3510	2490	2290	1030	3490	2450	3260	1020
Input—watts	33 350	17 410	9680	4890	33 350	17 410	10 790	4790	33 330	17 370	14 820	4780
Output—watts	29 840	14 920	7610	3760	29 840	14 920	8500	3760	29 840	14 920	11 560	3760
Efficiency—per cent	89.5	85.6	78.6	77	89.5	85.8	78.8	78.6	89.6	86	77.9	78.7

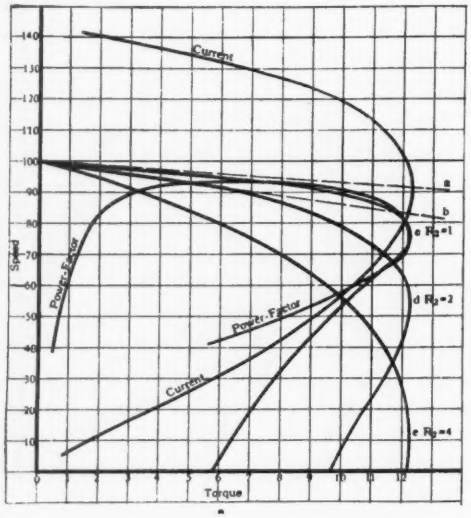


FIG. 2. SPEED-TORQUE CURVE OF AN INDUCTION MOTOR

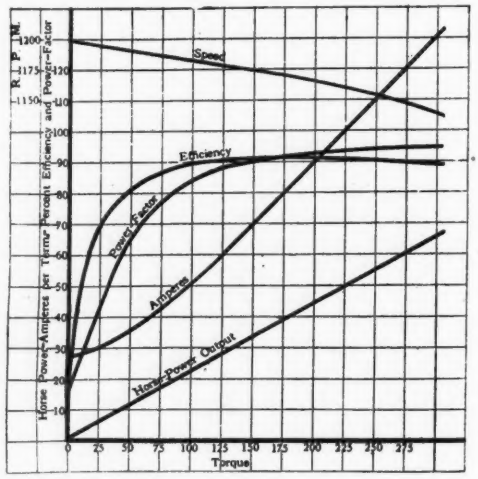


FIG. 3. PERFORMANCE CURVES FOR A 40-HP. 6-POLE INDUCTION MOTOR

Induction Motor With Secondary Resistance Control

In an induction motor, just as in a direct-current motor, the torque developed is proportional to the product of field strength and armature current; or to use the

terms ordinarily applied to an induction motor, torque is proportional to the product of primary flux and secondary current. When running at synchronous speed, the rotor conductors rotate with the stator field and do not cut the stator flux. At synchronous speed, therefore, no voltage is induced in the rotor, no current flows in the rotor, and consequently no torque is developed. To develop torque, therefore, it is necessary for the rotor to run at a speed less than the speed of the rotating stator field. The flux cut by the rotor conductors and the rotor voltage induced is then proportional to the difference in speed between the rotor and stator field, or to the slip. If the rotor resistance were constant, assuming no primary resistance or magnetic leakage, the rotor current and consequently the torque would be proportional to the slip, or the speed-torque curve of an induction motor would have the form shown at *a* in Fig. 2. If the secondary resistance of this motor was doubled, to develop a given torque would require twice the secondary voltage or twice the slip required under the conditions for curve *a*. The speed-torque curve for this resistance would be that shown at *b*.

In an actual induction motor, primary resistance and magnetic leakage alter the shape of the speed-torque curves. Instead of the curves *a* and *b*, an actual motor will have curves in the form shown at *c* and *d*. However, in the actual motor the slip at any torque is still directly proportional to the secondary resistance as shown by curves *c*, *d* and *e*. The same current and power-factor curves apply for all three speed-torque

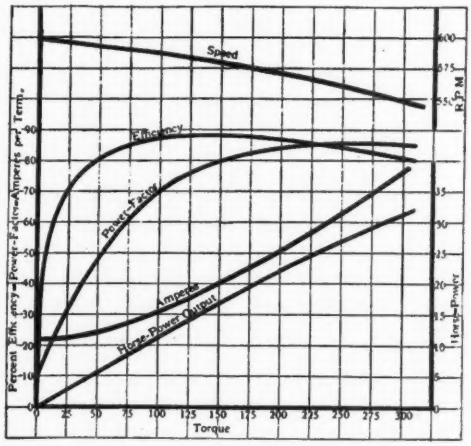


FIG. 4. PERFORMANCE CURVES IN THE 40-HP. INDUCTION MOTOR WITH 12-POLE STATOR CONNECTIONS

curves. For a given torque, then, the speed of an induction motor may be reduced by increasing the rotor resistance without affecting the power factor or primary current. For an induction motor with speed control by rotor resistance driving a constant torque load, the input at reduced speed is equal to the input at full speed, and the output has decreased with the speed. The efficiency at the low speed then is equal to efficiency at full speed multiplied by the ratio of the low speed to full speed. This case is the same as a direct-current motor with speed controlled by armature resistance. Just as with the direct-current motor, if the torque changes with the speed, the efficiency at the reduced speed is equal to the efficiency when developing the low-speed torque at full speed, multiplied by the ratio of low speed to full speed.

Induction Motor With Pole Change Control

In an induction motor, speed may be changed by changing the number of primary poles. In general, only two combinations of poles are practicable. This arrangement, therefore, gives only two fixed speeds with no adjustment between these fixed speeds. For example, a 60-cycle motor may be wound so that its primary coils can be connected to give six poles with a corresponding speed of approximately 1160 r.p.m., also the primary connections can be changed to give twelve poles with a speed of about 570 r.p.m. This arrangement gives, in reality, two motor designs for the same full-torque, the high-speed motor having twice the full-load horsepower that the low-speed motor has. For the same torque, it is to be expected that the efficiency and power

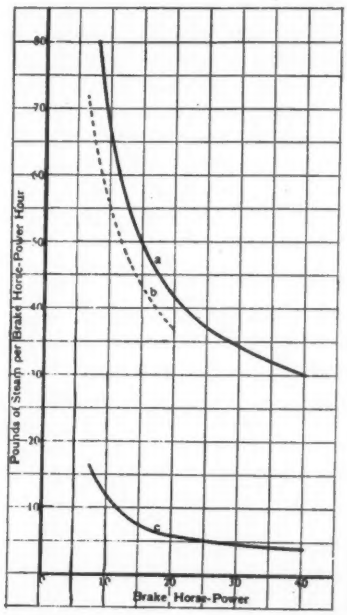


FIG. 5. STEAM CONSUMPTION OF NON-CONDENSING TURBINE

factor would be somewhat reduced with the low-speed connection. However, when two pole combinations are obtained with the same primary winding, both of these combinations cannot be equally effective. The primary winding is so designed as to be reasonably satisfactory for the small pole combination and, therefore, it is a winding of relatively high resistance and reactance in proportion to its effectiveness when used for the large pole combination. The efficiency and power factor at the low speed therefore, are considerably lower than at the high speed for the same torque at both speeds. Figure 3 shows performance curves for a 40-hp., six-pole motor, and Fig. 4 shows curves for the same motor with twelve-pole stator connections.

Small Steam Turbines

When steam is available for power, a choice of the most efficient type of drive cannot be made without considering the small steam turbine. In Fig. 5 curves *a* and *b* give the steam consumption of a non-condensing turbine of about 40 hp. Curve *a* represents steam consumption with two nozzles, and curve *b* is the steam

consumption with one nozzle. These curves are approximately correct for small ranges of speed adjustment. Where a turbine of this type can be used, the total steam consumption of the main plant probably is about 18 lb. per kw.-hr. Allowing an efficiency of 84 per cent for intermediate equipment, as transformer and motor-generator set, a steam rate of 21.5 lb. per kw.-hr., or 16 lb. per hp.-hr., is obtained for power delivered to the terminals of a direct-current motor. A motor with 90 per cent efficiency, taking power from the main plant, then will use 17.8 lb. of steam per hp.-hr. delivered. Comparing this figure with curves *a* and *b*, Fig. 5, it appears that an efficient motor drive is much more economical than a small turbine drive.

This is not the case, however, when the exhaust steam from the turbine can be used for feed water or general heating. Curve *C*, Fig. 5, gives approximately the steam consumption of the small turbine when the turbine is credited with the total heat of the exhaust steam. Comparing this curve with the figure of 17.8 lb. per hp.-hr. for the motor drive, it is apparent that the small steam turbine drive may be much more economical than a motor drive where a large part of the exhaust steam can be used.—The Electric Journal.

Hoisting and Conveying

Machinery Safeguards and Safe Operation. By the Engineering Department of the National Safety Council

About one-third of all industrial accidents occur in handling materials, the greater number of these accidents happening to workmen while handling material by hand, but the more serious accidents in connection with mechanical means such as overhead traveling cranes, freight elevators, belt conveyors, power-driven trucks, locomotive cranes, derricks of various types, chain hoists, electric hoists, or other means whereby the material is picked up and transported from one location to another.

Hand and Electric Hoists

For blocks threaded with manila rope as used for suspending scaffolds and for many other industrial purposes, particular care should be taken that the lashing or fastening to the upper block is safely and securely made, and of sufficient strength to sustain easily any load which may be hoisted by the block. The use of old rope and rusty wire for such fastenings should be avoided.

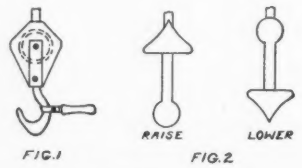


FIG. 1. HOOK FOR HOIST WITH SAFETY HANDLE FOR PLACING AND HOLDING IN POSITION

FIG. 2. USE DIFFERENT SHAPED HANDLES FOR "RAISE" AND "LOWER" HANDLES ON CONTROL ROPES

Chain hoists, used in locations where overhead cranes cannot be installed on account of low head room, also for handling heavy pieces at machines, should have all parts which sustain load made of steel rather than of cast iron. It is better to use hoists of a capacity larger than the regular work requires, to get a large factor of safety; for the tendency is often for workmen to overload hoists, and danger of accident to the men and of damaging work in process is less where ample hoist capacity is provided. Each hoist should have an automatic braking device to hold the load when hoisting is stopped.

Care of Chains

As a matter of economy, chains and sheaves should be lubricated at intervals sufficiently frequent to keep them in good wearing condition. Once a week in locations where dust and grit are likely to get into the chain; once a month in shops where conditions are more favorable.

Inserting bolts or nails in a chain to shorten it, as in the case where one side of a double chain has been stretched, puts a severe strain on the chain and often leads to accidents. Such practice should be prohibited, as should the splicing of a broken chain by inserting a bolt between two links, so that the head of the bolt and its nut sustain the load. Stretched or broken chains should be removed at once from service.

Care should be taken never to put load on a chain unless it is perfectly straight, with all kinks out.

Crystallization of chains is a matter on which opinions differ; and many do not believe that annealing is a satisfactory remedy. But it is certain that if annealing is to be done it should be in an annealing oven or bath, not in an open forge or bonfire where the temperature of the chain is a matter of guesswork.

Hooks must be of the right design and size to lift the loads without overstraining the metal, and forged steel is always to be preferred to steel castings which may have defects and blowholes not discoverable by examination. Very large hooks are well built laminated from steel plates to avoid interior strains.

To avoid pinching of fingers between hook and load, it is well to have a handle at the back of the hook by which it may be placed in position. If a hook is bent by overloading, never straighten it and put it back into service. The metal has been weakened and sooner or later an accident will follow. Get a new hook.

All hooks should be plainly marked with their capacity. A good way is to paint the hook block white and on this background paint the capacity in red letters and figures. It is a danger signal against overloading and makes the block easily discernible to the operators.

Electric Hoists

To prevent such hoists from over-travel, in case the operating handle is not thrown in time, a reliable limit stop should be provided.

Many accidents have resulted because an operator mistook the lowering handle for the hoisting handle or vice-versa. It is suggested that the handles of control ropes be distinctly different in shape so that, even with-

out looking, the operator will know which is the hoisting and which the lowering handle, thus enabling him to watch the work closely while operating the hoist. A spreader through which the control ropes pass and which will keep them separate is also advisable. Each also should be clearly marked "Hoist" or "Lower"; some companies attach to each control rope an arrow pointing in the direction the load will move in case that rope is pulled.

No attempt should ever be made with a monorail hoist to lift or move a heavy object by a side pull. Such a practice is not only liable to spread or break the trolley frame, but is also apt to loosen the I-beam supports. One of the greatest hazards in the operation of overhead monorail systems, whether operated by a chain hoist, electric hoist, or from cage, is introduced by the necessity for having turnouts or switches, and turntables, as trolleys frequently run off the ends of I-beams (tracks) when a switch has been left in the open position, often with serious results. It is important therefore that a stop be provided at all switches and turntables which will prevent the trolley from running off should the switch be turned or be left in the open position.

One member of the National Safety Council has installed electric signal lights (green and red) at all switches and turntables, on its electrically operated monorail system, these lights automatically changing as the switch is operated and indicating to the cranemen whether the track is in the open or closed position.

Some serious accidents have resulted when monorail cranes have fallen due to failure of suspension pins by which the load is supported from the trolley frame. It is advisable that every monorail hoist be equipped with one or more safety catches which will support the load should a suspension pin fail or the trolley frame spread.

Air Hoists

Hoists consisting of air cylinders mounted on hangers or trolley carriages and operated by air pressure are in general use in many manufacturing plants. The hazards in their use are about the same as with the electric or chain hoists. The operating handles should be of different shape, so that workmen will be able to tell which handle to pull for hoisting or lowering without actually having to look at the handles.

The lock nut which holds the piston on the piston rod should be secured to the rod by a castellated nut and cotterpin.

The method of attaching air hoist cylinders to trolleys or support is also of importance. A clevis should be used, or other means taken to prevent the hoist becoming detached from the hanger.

Cranes

At the end of the arm of a jib-crane a substantial stop should be provided to prevent the trolley from running off the end of jib. Side pulls should not be made with a jib-crane, but the jib arm should be directly over the load when making a lift.

The gears of all cranes should be enclosed, and if hand-operated by means of a crab or winch it is important that a locking dog be provided to hold the load when the handle is released. The greatest danger to the operator in the use of crabs and winches is that of being struck by the revolving handle. It is important that some form of brake or safety lowering devices be provided on all crabs and winches. For rapid lowering of the load, a strap brake is perhaps most practical.

Locomotive Cranes

No one piece of equipment is more adaptable for handling material in industrial plants than the locomotive crane. These are coming into use more and more every day because they may be self-moved to any part of a plant where railroad tracks can be laid and because they can handle a great variety of work.

Every crane boiler should be provided with a reliable safety valve, a steam gage, water column, trycocks, and a gage glass of a safety type, or one with a reliable gage glass guard. Safety valves should be tested frequently and boilers inspected periodically.

The engine, whether steam or gasoline operated, should be protected by suitable safeguards to prevent operator from accidentally coming in contact with revolving or unprotected parts. The operator's platform should be of anti-slip plate or of wood to reduce the slipping hazard, a wood-slat mat being effective. The steam and exhaust piping in cabs should be arranged to provide a clear passageway from one side to the other. Two doorways should be provided, one on each side of the cab, to permit exit of the operator in case the crane should tip over.

It has been suggested that a heavy wire mesh screen be installed between the winding drum and the operator's station for protection in case the cable breaks.

Wherever electric power is used, be sure that the motor is thoroughly protected against the weather and that current-carrying parts are guarded against accidental contact, and to prevent the operator's being burnt by flashings. Pinion and gear drives should be completely enclosed. A disconnecting switch should be provided, also a suitable circuit-breaker with no-voltage release. Track rails should be well bonded and grounded.

It is recommended that there be conspicuously posted in every crane cab, a chart or table giving the tipping capacity (without outriggers in use) at various positions of the boom, or for various radii of the hoist block. Another chart should give the safe working capacities of the crane with outriggers. It is suggested also that plainly legible capacity plates be attached to each side of the crane cab. An electric indicator to warn cranemen in case crane is tipping is in use by some companies, which rings an electric bell whenever the crane wheels leave the rail.

To permit easy and safe access to crane cab, foot steps and hand-holds should be provided on the truck bed and also on the cab. Automatic couplers should be provided on both ends of the crane truck and so arranged that they may be operated by levers from either side of the crane. These couplers should extend far enough to clear the revolving boiler tank.

Every locomotive crane should be equipped with steam or air brakes for the truck wheels, especially when working on slippery rails or on a grade to enable the operator to keep the crane at all times under absolute control.

Many workmen have been killed or seriously injured when they have been caught by the revolving body of a crane and crushed against the truck bed. To guard

against such an accident, guard rails, which may be extended to keep men out of the danger zone are recommended. Many companies have rigid rulings permitting no one but the operator to ride on crane trucks. Others believing that such a ruling is unwise, install a foot-board and hand-hold across each end of the truck and permit members of the crew to ride on this foot-board.

Rail clamps should be provided at each corner of the truck, and should be securely attached to the truck to hold it in position while the crane is at work. Outriggers should also be provided for use when the crane must do work at a considerable distance from the track.

Lighting

It is important that sufficient light be provided in the cab of every crane to enable the operator to see clearly how to perform his work, and especially to see the water and steam gages distinctly.

Where it is necessary to use a kerosene lamp, it should be of substantial metal construction, supported in a permanent, rigid fixture, and fitted with a reflector to direct the light on the gage glasses and operating levers. Where electric current is available, electric lamps are, of course, desirable. A small lamp may be placed over each gage with a reflector to keep the light out of the operator's eyes, or one or more large lamps, properly located and rigidly supported, may be used. Where the crane is moved about the plant at night, a headlight and a tail light should be provided. Some companies equip their locomotive cranes with electric searchlights to facilitate working at night.

Operation

Locomotive cranes should not be moved except upon a signal from an authorized signalman. Whenever no signalman or switchman is employed, the operator should move the crane only under the orders of the foreman of the department in which the crane is working. A locomotive crane should not be swung across a railroad track into such a position that cars moving on another track would strike it, until the craneman and the signalman have made sure that cars are not being moved on the adjacent track. Care must be exercised by the crane operator when passing by corners of buildings or structures that the crane is parallel with the truck and the crane is directly in line with the track so that the boom or body will not strike such building or structure.

When moving the crane about the yard, the boom should be carried low enough to clear all overhead wires. It is not advisable that buckets and magnets be carried on the boom when moving from one location to another, although in some cases this must be done. No one except the switchman or signalman should be allowed to make couplings or throw a switch.

Electric Magnets

The electric magnet has proved to be a great time-saver in handling iron and steel. The great danger in the use of magnets arises from the fact that should the current fail, for any reason, the load will be dropped. No person should be permitted to stand or pass near where a magnet is being used.

It is of prime importance that the electrical circuit be maintained in perfect repair. It is recommended that, in every case, some means for taking up the slack cable (feed circuit) to be provided, which may be by a simple arrangement of pulleys and counterweights, or by an electrically operated take-up drum.

Construction Hoists

There is not space to go into the details of tower construction; the principal essentials are substantial diagonal bracings; ample ties to building or guy wires to the ground, carefully attached and regularly inspected; platforms of ample size and strength, with railings and toe boards, at each level where men must work; a substantial ladder, securely fastened, extending the entire height of the tower; bottom of tower to be planked in or screened in; the tower should be constructed only by experienced men and only such men should take it down afterward.

The engineer operating any hoist or derrick should be protected against falling materials by a plank roof, unless the engine or motor is placed at a considerable distance from the foot of the tower or derrick. Wisconsin regulations require a roof unless the horizontal distance from the hoist to the engineer is at least one-half the vertical height to which the material is hoisted. Cables running from the engine to the hoist should be enclosed or fenced off to prevent injury to workmen who might walk across this space without noticing the cables. Exposed gears on the engine should of course be carefully guarded.

During winter months, a housing around the boiler will give partial protection to the engineer against the cold. This is an important safety measure, as an engineer with numb hands cannot control his throttle and brakes properly nor act quickly in an emergency. Exhaust steam pipes should discharge so as not to obstruct the view of the engineer.

(To be continued.)

Concerning the Finished Product

By J. B. Dillon

In a recent lecture, "Opportunities in Engineering," Dean H. S. Evans, of the engineering school of the University of Colorado, said:

"We don't pretend to turn out engineers at the engineering college here, nor do they at other schools. We do not train the man for a specific job, but we do give him a thorough knowledge of the fundamentals of science and mathematics, so that he will not be a routine worker, but will understand the 'why' of a job."

The foregoing states the case in about as true, complete and unbiased a manner as it is possible to do. The same remarks will hold good for any profession and the finished product may be likened to the conifer or walnut tree that is taken from the forest. It must go through many processes ere we see the finished product, and only the process of experience will create in a college man the ability to stand—as near as is humanly possible—a finished product.

It is reported that at Grand Valley, Colo., a hydro-electric plant is to be established by the Columbia Oil Shale and Refining Co. Grand Valley is in the neighborhood of Debeque, where the shale oil business is growing to large proportions.

Vacation Adventures and Observations

WOOD-BURNING FURNACES; SAWMILL ACCIDENTS. BY OPERATOR

FIGURE 1 illustrates the furnace under a battery of 72-in. by 18-ft. horizontal tubular boilers, for burning hog scrap and sawdust. As shown, there is no dividing wall between the boilers, the grates extending the full width of both boilers and about 9 ft. back from the front to bridge wall. The sawdust and scrap came down the three spouts from overhead conveyor and dropped about half way between the front of the furnace and the bridge wall. There were eight other boilers in this plant, but each had its separate furnace. Natural draft was used, except that in case of special need there was a steam pipe connected so that it blew up the stack, creating induced draft. When these furnaces were loaded and working well, the boilers could be crowded as hard as any with coal-burning furnaces that I ever saw. The dotted lines show the scheme of connection to stacks, of which there are five for 10 boilers.

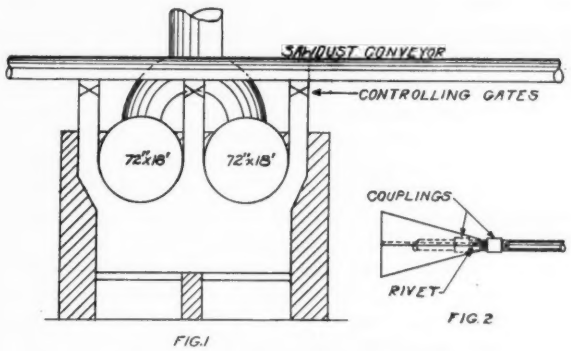


FIG. 1. SAWDUST-BURNING FURNACE
FIG. 2. HOMEMADE FLUE SCRAPER

When the fire was good and hot the fireman had to watch continually to see that the fire did not draw up the stack, as when it did it would take only a few minutes for the stack to get so hot danger of buckling and falling were imminent. The flue caps were left cracked open and as soon as fire showed through the flues the door was opened 3 or 4 in., which killed the flame.

One thing that surprised me was the amount of clinkers that were formed. Mud and sand carrying up on the logs was carried along with the sawdust and the clinkers were just like a hard-burned tile and would run through the grates like glue and set hard like glass. Every time the boilers were drawn a man would have to chip out the openings in the grate bars; but those boilers surely could make steam, unless a batch of white fir sawdust came over the conveyor. White fir in a sawdust fire is just about like feeding about ½ ton of sand on top of a good hot coal fire.

Another thing that surprised me was the amount of soot and carbonaceous scale that would collect in the tubes. These were scraped out once a week. The homemade scraper was very efficient and extremely simple, but could not be used in tubes that had been retipped, as it would catch the weld. It looked like a funnel, but had one rivet to hold it together as shown in Fig. 2. A piece of ⅜-in. pipe had a running thread cut on it with a coupling outside and one inside. The harder you screwed up on the outside coupling the tighter it fitted the tubes. Two boilers were scraped out after the mill was shut down and by the time two men ran it through the tubes they knew they had been working. Compressed air at 100 lb. pressure was used to blow the tubes after scraping and I believe did a better job than steam.

One night I had just oiled around and sat down by No. 1 engine for a minute, when I heard a crack and saw the connecting rod from the sawyer's lever fall down just as No. 1 whistle began to blow. I started for the main valve and by the time I arrived (distance about 30 ft., and two corners to turn) it looked as if the air was full of 1-in. cable, trying to throw loops over the 3-in. steam line, and it was some job dodging cable and shutting the valve. What happened was that the go-ahead cable broke loose from the carriage when the saws had got about 8 ft. into the log and the slack thrown got tangled up with the back-up cables, carrying them over the drum, reversing the carriage. The slack also caught the counterweight on the valve rod, breaking the arm on the rod and binding the rod so that the valve was wide open and could not be shut, and the sawer was helpless, as his lever was disconnected entirely. Eight hours were required to untangle and connect up cables.

This mill was rated at 100,000 ft. of lumber in 10 hr., but we cut over 133,000 in 8 hr. several different times.

If a man wants to get hair-raising experiences, and fast at that, let him go and get a job in a sawmill that is crowding everything for all it can stand, and then to help matters along, get the sawyers to bucking each other and he surely has his work cut out for him. If a man in any other factory or mill should handle an engine as I was forced to in that place, they would hang him.

Judging Efficiency by the System of Maintenance Employed

OVERALL EFFICIENCY OF A HOTEL POWER PLANT IS BUILT UP OF THE INDIVIDUAL EFFICIENCIES OF EACH MACHINE. BY GEORGE TALCOTT INGERSOLL

EVEN WITH good design and arrangement and with all first-class equipment, the ignorant and careless use of bad water will cause a steady depreciation and loss in efficiency, particularly if there has been no regular system of inspection and if there has been frequent change in chief engineers and assistants: for the hotel plant is intricate and it takes time for a new man to get his bearings.

To operate his plant efficiently, an engineer should be thoroughly conversant with every detail of his plant. This does not necessarily mean that he must rely upon his memory, but he must have a record of every piece of equipment under his charge, and should be able to refer to any such record at a moment's notice.

The condition of the plant, after a few years, is closely allied with the kind of water used, the general design and arrangement, the system of maintenance, and it furnishes an interesting clue or guide to the overall efficiency of the plant.

System of Maintenance

Passing along a business street not long ago, I saw the sign "Watch Inspector S. P. System." The watch inspector of a great railroad system is a very important and valuable man; his work is regularly to inspect the watches of those railway employes who are directly concerned in the running of trains. He must keep the railroad watch properly adjusted, regulated, cleaned and oiled so that it will run at highest efficiency; that is, keep accurate time. For the safety and comfort of the many millions of passengers, the railroad officials know that a regular inspection of the watches of their employes is necessary. If the trainmen were allowed to carry any grade of watch, to give them improper care and have incorrect time, there would be much confusion and many accidents. The watch is for service and the railroad is for service and the hotel is for service. If an inspector is necessary for the watch and the railroad is he not also necessary for the hotel? How many modern hotels have an inspector?

The inspection system applied to the hotel would mean that a competent and experienced man known as the "Inspector" is chosen whose duty it is to inspect carefully every part of the machinery and equipment at least once each week, and make a report particularly as to any part that needs repair or renewal. He should have access to detail drawings, specifications and repair lists of every machine in the plant. He may have charge of the repairs needed or that may be done by some other man selected by the chief engineer. The point is to have needed repairs made without delay and a proper record made of the work, the philosophy of which is as old as the hills—"A stitch in time saves nine."

The right type of man for this inspection work will soon become expert in the work; his senses will become acute and he will learn to detect the small leaks and losses which, uncared for, run into big losses.

Too many hotels use a plan which I would call the "take it easy" plan, which means never bother about repairs until you have to or there is a breakdown and all hands jump in to repair the trouble. Get her running again and then take things easy until another breakdown.

Troubles in the hotel power plant, as elsewhere, are apt to come at the wrong time and, by the second plan, they will accumulate with more and more loss and waste as time goes on; and so the system of repair and maintenance used is a good index and clue to the efficiency of the whole plant.

Efficiency of Each Machine

To obtain high efficiency in the hotel power plant, it is necessary to have high efficiency in each machine.

No other one machine in the hotel power plant is as important as the boiler and none is so difficult to operate at high efficiency. The writer well remembers the time when a man who was not good for anything else around a power plant was sent to the boiler room to shovel coal just as the farmer boy who was not smart enough to work in the store or factory was left on the farm to be a farmer.

Now we are told that the annual unnecessary waste and loss in the use of fuel in this country runs into nearly one billion dollars. Something must be done to reduce this loss and the hotel power plant can help.

There are really two problems to boiler operation. One is the boiler efficiency, which has to do with the water and its evaporation into steam. The other is the furnace efficiency, and has to do with the fuel used; the boiler settings, walls, chimney or mechanical draft, dampers, soot cleaners and regulators, type of grate, combustion space, arches, wing walls and baffles.

It is of first importance that the boiler be kept clean outside and inside. It is far cheaper and easier to clean a settling tank or a feed-water heater and purifier than it is to shut down and clean out a boiler.

For high efficiency in the furnace, the combustible gases and air must be properly mixed at all times and not just once an hour or once in eight hours.

The study of combustion is most important and interesting and should have the earnest attention of every power plant man. The way has been made easy for those who need help and there are several good recording instruments now on the market which can be applied in a way to simplify the problem.

The chief engineer should have complete specifications, blueprints and shop number of the boiler and every other machine in the power plant with the guarantees of the manufacturer for the machine in use. He should also have a descriptive catalog and a list of repair parts which may be needed for each machine. This will give him his general information. He should next learn whether each machine is working up to the guarantee made by the factory or agent at time of purchase. If it is not, he should seek the cause and perhaps report to the factory. Any responsible manufacturer is always glad to know of any defect or failure in performance and will make good. The chief engineer should also know whether each machine in the power plant is the best that can be had for the work. New and better design and material have in some classes of machines made possible a much better efficiency, and there comes a time when it is good business and good economy to replace an old machine with one of newer design and higher efficiency; hence, it is very important for the chief engineer and his assistants to read the technical journals which describe and advertise power plant machinery and, when interested in some particular machine, send for catalogs.

Thus the efficiency of each machine in a hotel power plant gives me a very quick and fairly accurate clue to the overall efficiency of the plant, for the overall is made up of the efficiency of each unit.

A one-reel film, entitled "A Dollar Saved Is a Dollar Earned," which picturizes how the coal bill can be cut down in the average home by the insulation of boiler and pipes, has been presented to the United States Bureau of Mines library of educational films, and will be circulated by the bureau throughout the country. In addition to this circulation, prints of the films will be available to distributing agencies, such as the Red Cross, Y. M. C. A., etc., which loan education films to churches, schools and lodges without rental charge, the same as a Carnegie library loans books free. The picture was produced under the auspices of the Pipe and Boiler Manufacturers of the United States by the Rothacker Film Co., of Chicago.

Some Recent Experiments on Lubrication

By J. H. Blakey

THE English National Research Laboratory has just published its first report relative to its experiments on the subject of lubrication. La Revue Generale des Chemins de fer, for April, gives the principal conclusions arrived at.

The first tests were made on the different oils which have been proposed for aviation motors: they have been carried out with the aid of a machine constructed by M. F. W. Lanchester for testing automobile worm transmissions. It consists essentially of a worm gearing and a toothed wheel running in oil, permitting the measurement of the couple acting on the shaft of the worm and that on the shaft of the toothed wheel. The relation of the resistance to the work done by the motor gives the efficiency of the gearing.

Tests of mineral oils show that they all have a critical temperature beyond which the gait of the machine becomes unstable and the efficiency of the transmission diminishes. There has not been established, at least up to 75 deg. C., critical temperatures for animal and vegetable oils. The efficiency of these oils exceeds 95 per cent; that of the mineral oils is slightly lower. An addition of 2.5 per cent of colza to a mineral oil raises its critical temperature but has no sensible effect on its efficiency. The addition of about 2 per cent of "oildag," which is a colloidal graphite composed of 12.1 per cent graphite, 0.6 per cent mineral matters and 87.3 per cent of an oil soluble in ether, seems to render mineral oils of inferior quality equal to those of higher quality. The addition of graphite to animal oils results in an improvement in the quality, but has no effect on oils of vegetable origin; it also raises by about 18 deg. C. the critical temperature of mineral oils. As regards viscosity, or internal friction, it is established that it increases considerably with high pressures; for a mineral oil, the viscosity is 25 times as great at 13,000 lb. per sq. in. as it is at atmospheric pressure; for neat's foot and castor oil, the increase in viscosity is only 4 to 1. The laboratory has determined the physical constants for lubricating materials, and for certain non-lubricating materials, such as glycerine, glycol, sulphuric acid, etc. These results have not been made public.

When a metallic surface resting upon another is displaced, friction is set up; the displacement is produced beginning with a certain effort and continuing with a lesser effort; there are two coefficients of friction: the starting or statical coefficient, and the sliding coefficient. There are different cases of friction in the parts of machines: friction without lubrication, or dry friction, and the rolling friction of surfaces separated by rollers or balls; friction with lubrication, which is divided into imperfectly lubricated friction between two surfaces covered with a film of grease, and into viscous or perfectly lubricated friction, produced in the layer of the lubricant which separates the two metallic surfaces in relative movement.

Exact data on dry friction are lacking. For rolling friction, Prof. Goodman has shown that it is not diminished, if it is not increased, by the lubrication of the balls. The coefficient of friction diminishes with plane and increases with grooved rolling surfaces; it remains almost constant at all speeds, is independent of the temperature of the bearing and is the same at starting as while running; it is less with large than with small balls. The wear of the balls is negligible.

Concerning the ordinary or imperfectly lubricated friction, Dunstan and Thole consider that lubricants must be placed among the iso-colloids; polyphase systems in which the components are of the same chemical nature as the medium of dispersion. Ostwald has shown that a colloid at contact with a surface has not the same distribution of its elements as in its mass; there is a concentration at the surface contact. This special concentration has received the name of "adsorption." Hardy has recently found that a layer of one millionth of a millimeter in thickness of a good lubricant is sufficient to start the sliding on one another of two surfaces of glass with the minimum of friction.

Experiment shows that when a shaft turns in an automatically lubricated bearing, with a film of oil of from 0.02 to 0.005 of a millimeter in thickness, the coefficient of friction at constant temperature is proportional to the speed, to the area of surface and to the viscosity, and independent of the pressure and of the nature of the two surfaces. Michell has given a complete theory of rolling in a viscous liquid in the three dimensions for plane surfaces. From it he has constructed his remarkable bearing, which is perfectly lubricated and without wear of the surfaces.

To sum up, we have three cases of friction: 1, Non-lubricated surfaces, or dry friction; 2, surfaces partially lubricated, or fatty friction; 3, surfaces perfectly lubricated, or viscous friction. In the first case, the rubbing surfaces are separated by a film of air; in the second, by a film of lubricant "absorbed" by the surfaces; and in the third, we have a solid moving in a liquid. The approximate coefficients of friction are respectively 0.1 to 0.4, 0.01 to 0.1, and 0.001 to 0.01, in the three cases.

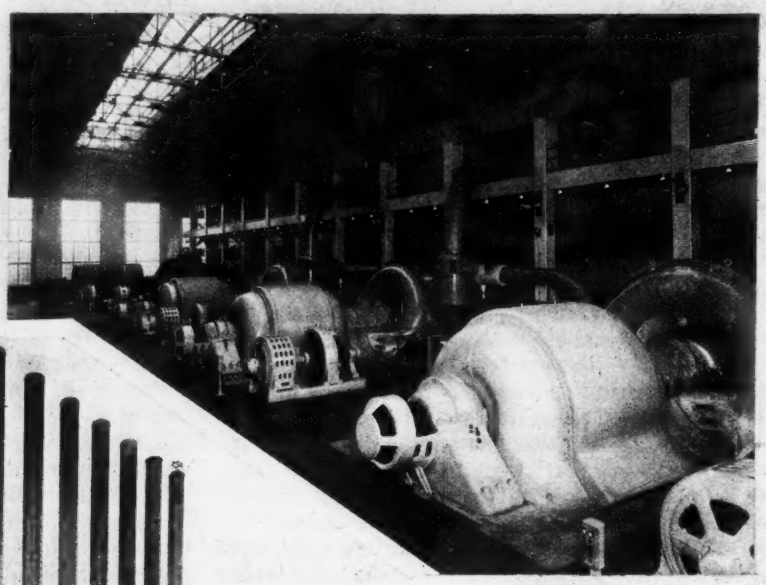
Finally, there remains much to be done in the study of the physical properties of lubricants, and of the chemical reactions produced in the bearings. We know that vegetable and animal oils are ethers of tri- and monovalent alcohol radicals, containing fatty acids, free and saturated. The others, small in number, particular to each oil, have been identified; their proportions are known, but we are still ignorant of the lubricating value of these ethers. As to the mineral oils, we know only that they are composed of hydrocarbons of different series, some saturated, others not; but we are ignorant of the chemical constitution of the hydrocarbons particular to each oil, and we know nothing of their lubricating value.

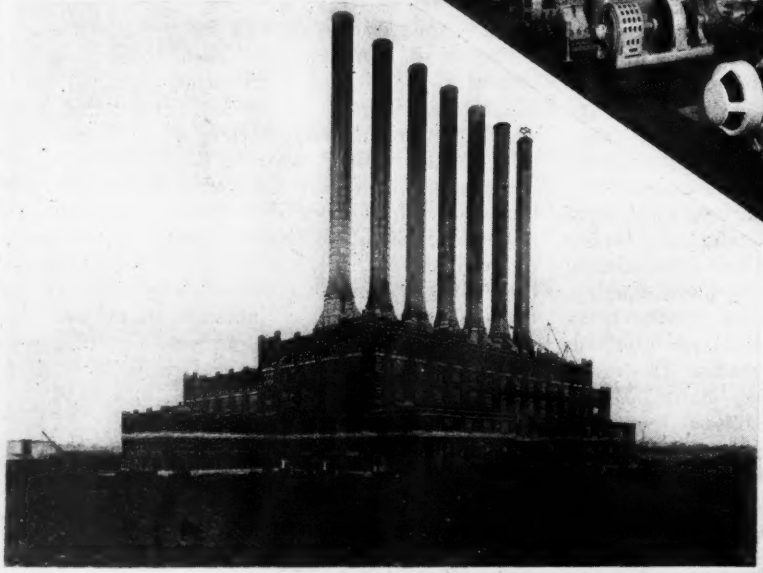
Washington heralds the news that the lightest wood known has been found. It is lighter than cork. Its name is balsa and it grows in the tropics.

A prominent use is that of refrigerator linings and for use in ice boxes. If it is such a good insulator, perhaps it will make an excellent covering for steam pipes or for any piping where steam heat, or chilled air is desired to be maintained as near a certain temperature as is practicable. Anyone interested might write the Director of the National Museum, Washington, D. C.

Views at the Connors Creek Plant of the Detroit Edison Co.

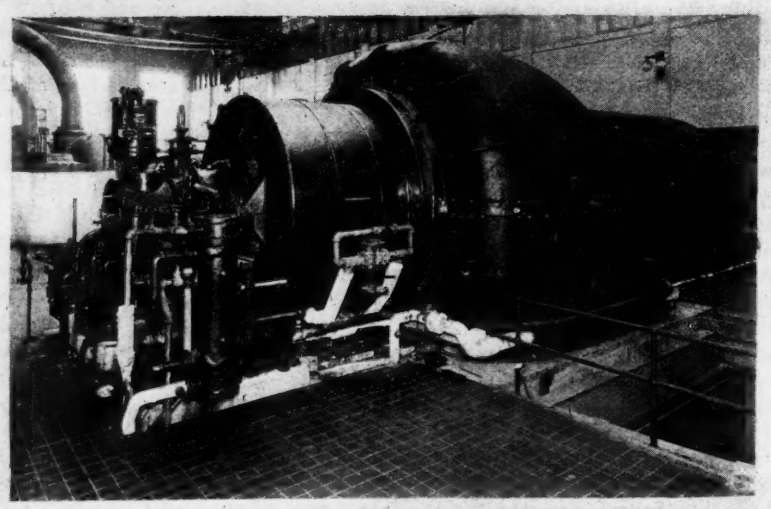
Right. The turbine floor of the Connors Creek plant of the Detroit Edison Co. Three 20,000 kw. turbo-generators are shown in the foreground and beyond them one of the 45,000 kw. units. Since this picture was taken a second 45,000 kw. unit has been installed at the far end of the room, and a 30,000 kw. unit in another part of the power house.





Left. Exterior view of the Connors Creek plant of the Detroit Edison Co. It contains 14 2300-hp. boilers, and generating units totaling 180,000 kw. capacity. This plant is situated at the head of the Detroit River, about six miles from the center of the city and with the company's other generating stations serves Detroit and the territory for about 50 miles around.

Right. One of the two 45,000 kw. turbo-alternators at the Connors Creek plant. This is a 21-stage turbine of the Curtis type, direct connected to a 12,200 v. generator with a normal speed of 1200 r.p.m.



Electrically Heated Steam Boilers

WHERE ELECTRIC POWER IS CHEAP THE ELECTRICALLY HEATED BOILER HAS A DISTINCT FIELD OF USEFULNESS. BY ERIC A. LOF

THE GENERATION of steam by electric current opens up a new industrial field for the utilization of electric power. Its universal use is, however, as yet impossible for economic reasons, but there are many special cases where its application will result not only in a direct economical saving but also in many advantages from an operating standpoint. One particular field where the electric boiler should prove very desirable is in connection with hydro-electric central stations where power can as a rule be obtained at a comparatively low rate and where combustible fuel is generally scarce. Other fields are such industries that rely upon central stations for their power supply and whose manufacturing industries require steam but who desire to do away with the coal fired boiler installation and its many unpleasant detriments. When circumstances are such that excess power is available at certain times, generally at night and on holidays, the economical advantages of an electric boiler plant are apparent; and the possibilities of storing up this surplus power or at least part of it as heat in so-called vapor-accumulators offers many new and interesting problems.

From the technical point of view the electric boiler problem, in general, does not offer any great difficulties and a large number of such boilers are now in successful operation in all parts of the world. Their construction is simple; they require very little floor space and are easy to install on account of the absence of brick settings, stacks, etc. By carefully heat insulating the boiler it is possible to reduce the heat losses to such an extent that the efficiency of electric boilers of average size may be as high as 96 to 98 per cent. The operating force can be reduced to a minimum, and even when the workmen are poorly qualified the automatic control devices will insure that the normal quantity of steam is continuously obtained under even pressure and without the risk of dry-boiling followed by the liability of explosion, which here is quite non-existent. The steam pressure in the boilers can be raised very quickly, in certain cases even within as short a time as 10 min. from the moment the current is switched on, a fact of great importance especially for intermittent working.

In connection with labor saving, it might be interesting to learn what has been accomplished in a large paper mill in Sweden where the electric boiler installation consists of not less than seven 2000-kw. boilers operating at a potential of 10,000 v. and a steam pressure of 10 atmospheres: "In comparison with our old coal boiler plant we now save the expense of all hands, tonnage and rolling stock, otherwise required for the transport, reloading and discharge of coal and ashes, amounting to about 65 tons a day."

In comparing the relative heating values of fuel and electric heat, we have first the fundamental conversion factor of one kilowatt hour equalling 3412 B.t.u. With an electric boiler efficiency of 96 per cent, this figure would be $3412 \times 0.96 = 3275$ B.t.u. We also find from steam tables that to raise the temperature of 1 lb. of water from, say 60 deg. F. to 212 deg. F. and then to that of a gage pressure of, say, 100 lb. per square inch there are required 1158 B.t.u. Consequently $\frac{3275}{1158} = 2.82$ lb. of such steam can be generated per kilowatt-hour in the electric boiler.

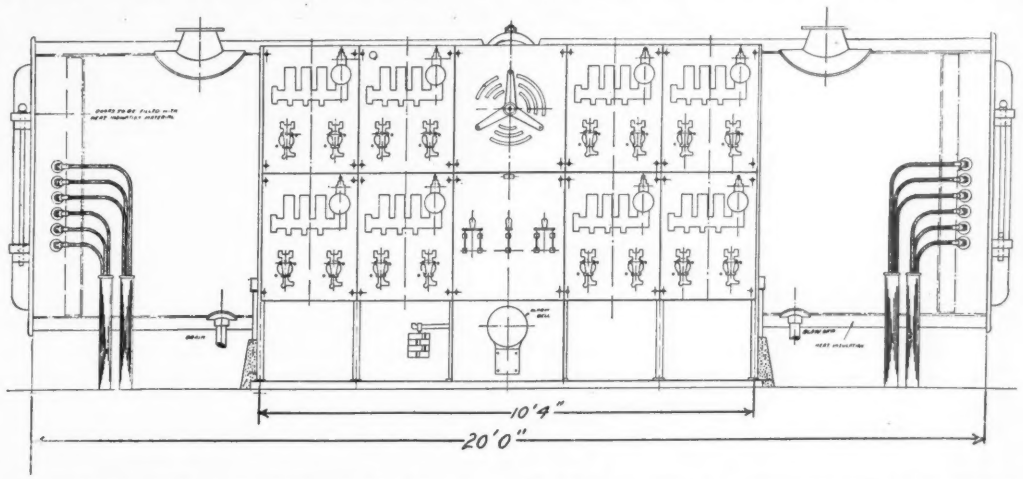


FIG. 1. DIAGRAM OF ELECTRICALLY HEATED STEAM BOILER OF THE METALLIC RESISTOR TYPE TOGETHER WITH CONTROL BOARD FOR AUTOMATICALLY MAINTAINING STEAM PRESSURE

Assuming a heat value of 14,000 B.t.u. for the fuel which would be burned in the ordinary boiler and that the average efficiency of these is 70 per cent we find that this boiler will produce $\frac{14{,}000}{1158} \times 0.70 = 8.5$ lb. of steam per pound of coal. Previously we found that in the electric boiler 2.82 lb. of steam would be generated per kilowatt-hour and the ratio of evaporation between the two types of boilers would be $\frac{8.5}{2.82} = 3$. One kilowatt-hour with electric heating would therefore corre-

spond to one-third of a pound of coal. With coal at $5.00 per ton (2000 lb.) the cost of fuel to generate 1000 lb. of steam would be $\frac{1000}{8.5} \times \frac{5}{2000} = 0.3$ dollars. To generate the same amount of steam in the electric boiler there would be required $\frac{1000}{2.82} = 355$ kw.-hr.; and in order that the power cost for the electric heating should not exceed the cost of fuel for the ordinary boiler, it would be necessary to obtain power at not more than $\frac{30}{355} = 0.085$ or less than one-tenth of a cent per kilowatt-hour. This is, of course, only possible in localities where cheap hydro-electric power is available or on the other hand, the cost of fuel may be so high as to make the economical utilization of electric heating look more favorable. The foregoing figures refer, of course, only

FIG. 2. ONE OF THE RESISTOR HEATING UNITS FOR BOILER SHOWN IN FIG. 1

to the cost of fuel or power and they do not include the operating and maintenance charges which are very much reduced with the electric boiler.

In the rating of steam boilers by horsepower, one horsepower is equivalent to 33,480 B.t.u. As previously stated, one kilowatt-hour is equivalent to 3412 B.t.u. so that for all practical purposes one boiler horsepower is equal to 10 kilowatt-hours of electric energy. A 100-hp. electric boiler therefore would be rated 1000 kw., a 150-hp. boiler 1500 kw., etc.

Electric boilers may be classified in two distinct groups: first, boilers in which the water is heated by means of resistances mounted within the boiler; and, second, boilers in which the water itself comprises the resistance which is heated when the electric current is passed directly through it from electrodes immersed in it.

Either direct or alternating current may be used with the first named type of boiler having resistance heating elements, as these elements do not come into direct contact with the water. With electrode boilers, however, it is essential to use alternating current as direct current would have a decomposing effect on the water.

There are, of course, a variety of different constructions employed for electric boilers. One of the most satisfactory resistance-unit boilers in this country is the fire-tube boiler. This is admirably adapted to electric heating as the heating units can readily be inserted and supported in the tubes and adequately insulated from them. The heating units in these boilers are a modification of those which have been used for years in large electric resistance furnaces. The unit consists of a heavy ribbon of resistance alloy, supported at frequent intervals by suitable insulators which are clamped to the resistor and are of such size that the unit when assembled will slide freely into a boiler tube.

The sketch shown in Fig. 1 shows an outline of a 1500-kw., three-phase, 440-v., electrically-heated steam boiler with control board for automatic pressure control, and Fig. 2 shows one of the heating units.

The second type of boiler which is as yet comparatively new in this country, but which is quite universally used in Europe, is designed on an entirely different principle than is the resistance-unit boiler. Electrodes, usually of iron, are immersed directly in the water and the current is led to them through leads which pass through the boiler cover through steam-tight insulating bushings. On account of the high resistance of the water and a suitable arrangement of the electrodes, it is possible to utilize currents of a very high voltage directly. Several such boilers are in operation using an electrode voltage of 10,000 v. and it is said that twice this voltage may be used successfully for the larger sizes.

FIG. 3. A BATTERY OF 2000 KW. STEAM BOILERS IN WHICH THE WATER ITSELF COMPRISES THE HEAT GENERATING RESISTANCE

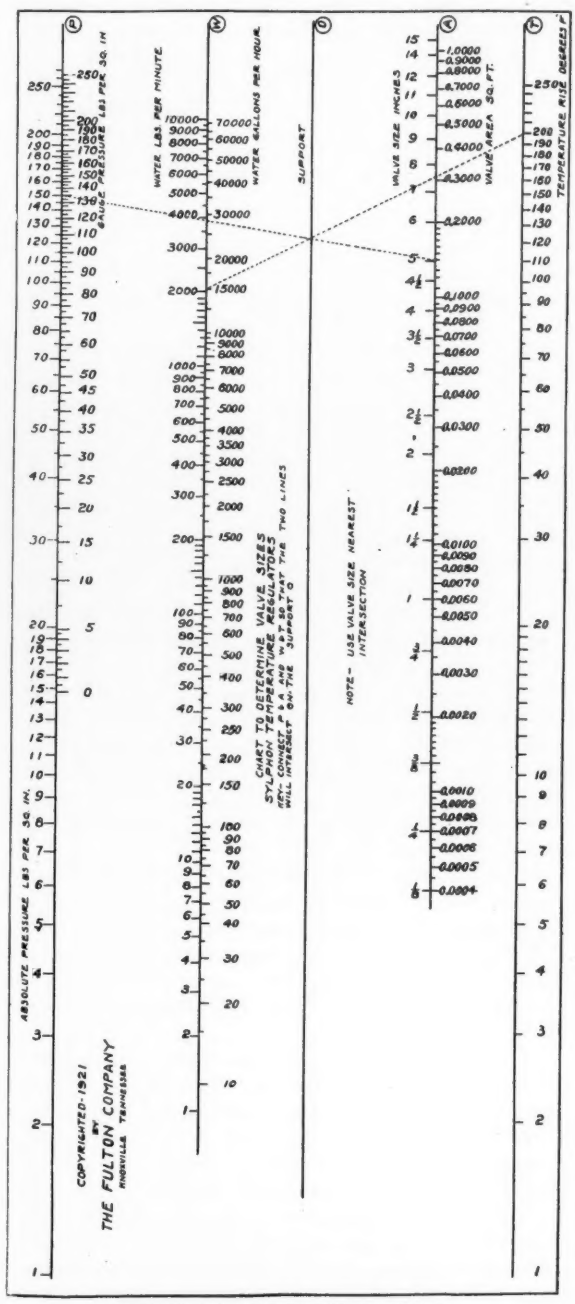
Electrode boilers have been built in capacities up to 4000 kw., and it is claimed that there would be no difficulty in building them for twice this capacity.—General Electric Review.

Temperature Regulator Chart

IN FIGURING the size of valve to accommodate any given pressure and flow it has been necessary to resort to a rule of thumb method which has been not altogether satisfactory. In calculating regulator valve sizes, the tendency is to figure too high. Too large a regulator not only adds to the initial cost, but results in only cracking the valve for small openings which produces a wiredrawing action with its consequent loss.

To be able to determine with greater accuracy regulator valve sizes, the Fulton Company has prepared the accompanying alinement chart which is called a temperature regulator chart. The chart shows four quantities which are usually considered in these calculations; P, steam pressure in lb. per sq. in. absolute and gage; A, valve size in inches and area in square feet; W, quantity of water heated per hour, pounds and gallons; and T, temperature rise of water, deg. F. When any three of these quantities are known, the other may be found. For instance, if the valve size is wanted for any set of conditions, connect T and W with a straight line and then from P extend a line through the intersection of the first line drawn with the fixed line O, called the

support, to cut the scale A to give the size valve and the area. For instance, to heat 15,000 gal. of water per hour from 40 to 240 deg. F. in a closed heater with


ABSOLUTE PRESSURE LBS PER SQ. IN.
GAUGE PRESSURE LBS PER SQ. IN.
WATER LBS PER MINUTE
WATER GALLONS PER HOUR
SUPPORT
VALVE SIZE INCHES
VALVE AREA SQ. FT.
TEMPERATURE RISE DEGREES F.
CHART TO DETERMINE VALVE SIZES
SYLPHON TEMPERATURE REGULATORS
NOTE- USE VALVE SIZE NEAREST INTERSECTION
COPYRIGHTED 1921 BY THE FULTON COMPANY PINDVILLA TENNESSEE

TEMPERATURE REGULATOR CHART

steam at 135 lb. gage, we find as indicated on the chart that a 5-in. valve would be required.

Price Deflation

TO SHOW price fluctuations since 1914, Dwight P. Robinson & Co., of New York City, have prepared an interesting chart with lines for nine principal commodities and an average line, which is well worth studying by those who are watching for a turn in business. The chart includes farm products, metals and metal products, food, chemicals and drugs, cloth and clothing, fuel and lighting, lumber and building materials, housefurnishing goods, and miscellaneous. During 1914 and the first half of 1915 there was comparatively slight fluctuation, food showing a rise of 16 per cent in August, 1914, followed by a drop in December to 5 per cent above 1913 prices, and metals dropping steadily to a low point 19 per cent below 1913 prices, then rising to the 1913 level in July, 1915. In September, 1915, all materials began an upward shoot, which with some fluctuations downward from time to time reached a peak in 1920. Two exceptions were metals, which reached the peak in July, 1917, of 257 per cent of 1913 prices, then dropped to 174 per cent in December, 1917, and with some wide variations rose to 194 per cent in April, 1920, and chemicals, which reached a peak of 252 per cent in November, 1917, dropped back gradually to 171 per cent in July, 1919, and rose to a lower peak of 222 per cent in October, 1920.

Since October, 1920, when housefurnishings and fuel reached their peaks, the decline in all prices has been steady. Housefurnishings as of July, 1921, show the highest level above 1913, being 250 per cent; lumber was at 212 per cent and showed a tendency to hold steady; fuel and lighting were at 187 per cent; clothing was at 180 per cent with the decline halting; chemicals were stabilizing at 166 per cent; metals and their products were at 132 per cent; food was at 130 per cent; and farm products were at 113 per cent. Of the fundamentals for power plants, metals, fuel and lumber groups, the first has dropped about three-quarters its peak rise and is down 60 per cent from 1920 values; the second has lost one-half of its rise and is down 90 per cent from 1920 values; the third has lost nearly 60 per cent of its rise and is down 139 per cent from its 1920 maximum. All percentages are of 1913 prices. It would seem, therefore, that deflation of prices of plant material is practically completed, and this is indicated by the fact that contracts are being awarded more rapidly than for a long time. Not much industrial construction is going forward, but Dwight P. Robinson & Co. believe that when any large volume starts, the demand for material will push prices upward from the present level, and they do not look for any further reduction of consequence. The figures from which the chart was plotted were taken from reports of the Bureau of Labor Statistics, U. S. Dept. of Labor.

Regarding Oil Shale

IN discussions concerning the shortage, present or impending, of petroleum, it is often argued that though there be oil bearing rocks in abundance, the cost of extraction would be practically prohibitive. While this is true as long as our present abundant, accessible and cheap supplies of free petroleum continue, and under present methods of refining, there will come a time when distillates from rock shale will compete favorably in price with imported petroleum, and against such a condition our future appears adequately bulwarked. It is illuminating to recall that oil shales have been distilled with financial success in Scotland since 1850, that there are at the present time five operating companies, four of which also carry on refining operations. The total invested capital is about £3,000,000 and approximately 10,000 men are employed underground and on the surface.

Grounded Lines; Motor Speed

A REPORT was turned in to the effect that the lights on a certain circuit were all burned out; and as it was a three-wire system, I supposed at once that the neutral fuse was gone, and was much surprised to find that such was not the case; in fact, the neutral, instead of being fused, had been permanently coppered.

Nevertheless a test across the line in question showed a potential of 220 v., while all the other circuits were normal. The intermittent nature of this trouble made it all the more difficult to locate.

By test a ground was located at B, also one at A. This last ground was intermittent because of the switch E, the ground being effective only when this switch was closed. At such times the current from line O flowed through ground A thence to B, through fuse C and to the neutral N. As this made a direct short circuit, the fuse C was blown, thus removing one side of this circuit

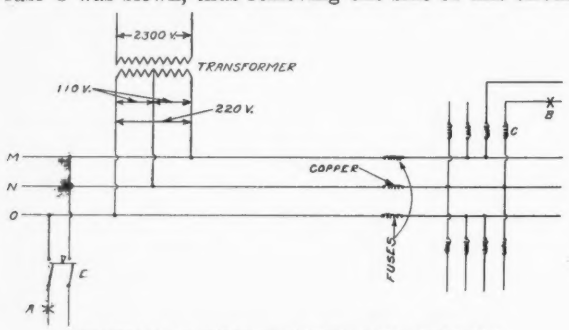


DIAGRAM OF CIRCUIT WHICH GAVE TROUBLE

from its normal connection to the neutral and leaving it connected, by means of the two grounds, to the line O, and as the other side was connected to the line M it gave the circuit a difference of potential of 220 v.

As the ground A was on other premises and not under my control, I corrected my part of the trouble by removing ground B and having a permanent ground made on the neutral at the transformer, which is in accordance with the best wiring practice.

This removed all trouble on my lines, but of course left the ground A, which, however, would be sure to show itself, making it easy of removal, the first time switch E was closed.

Referring to question 11, page 685, July 1 issue: I would suggest that the rotation speed of a direct-current motor may be increased by introducing resistance into the shunt field winding, in case of a shunt or compound motor, or by means of a bypass around the field of a series motor. This will lessen the field flux, consequently the counter-electromotive force, resulting in an increased armature current, which will produce an increase in the speed.

There is a limit to the speed which may be obtained in this manner, as the weakening of the field also decreases the torque, or force to turn, which would eventually become insufficient to pull the load and the motor would stall. Weakening the field of a motor to increase its speed is analogous to shifting to a higher gear in our automobile to increase its speed, which result is obtained so long as the load is not too great. On trying to climb a steep hill, however, on a high gear, we find it impossible, as the engine will stall, just as the motor does when the field is made too weak for the load.

J. M. Row.

Water for Hotel

IN a recent issue of Power Plant Engineering there appeared an article relating to the water question as applied to hotels. In a certain paragraph of this article its writer expresses himself as able to judge the efficiency of a hotel power plant in the following manner: "The analysis of the water, then, the quantity used, its effect on various machines and the number of visible leaks, give me a very interesting and important guide or clue to the overall efficiency of the plant."

Such a statement should put every engineer up on his toes for the public generally judges his services by the leaks it sees, which is decidedly unfair.

I wish to state my practised opinion on the subject as attested by numerous, long, hard years, as a hotel chief engineer in many and varied plants from Maine to Texas.

It is a common saying among hotel chiefs that we are all well prepared for the next world inasmuch as the longer we stay at the game the less fear we have of the terrors of Hell; and the word always spelled in capitals, is forever a part of daily routine. It is a truly thankless job, say what you may.

A guest at a hotel little realizes to what an extent he is indebted for his comfort and service, not to the management but to the chief engineer of the establishment. A hotel is a 365-day, 24-hour proposition as is a public utility outfit. Public utility chiefs are responsible, in most cases, for but one product, i.e., electricity or sewage or water, etc., but just count the products a hotel chief is responsible for,—water, sewage, steam, electricity, refrigeration, and a host of others. To make matters worse all these items must be kept synchronized at all times, for the failure of the water item alone will instantly throw the whole hotel organization out of gear.

When water supply fails—steam fails, sewage disposal fails, electricity fails, and refrigeration fails.

When refrigeration fails—thousands of dollars

worth of goods spoil; no ice is manufactured and a guest is forced to drink warm water.

When steam fails, through water failure or some other reason—no cooking can be done; no laundry, no current can be generated, no elevators can be operated and the hotel is plunged into darkness unless recourse is taken to emergency city service.

The one cry of hotel guests is *service*. That is what they pay for and it is what they expect.

Do they always get it?

Not unless every unit in the engine room is synchronized and *service* is being turned out.

Not only is it necessary that operation and efficiency be maintained at all times in the engine room but the organization of men who cater more directly to the guest's wants, must be intelligent and painstaking workmen. I refer to plumbers and electricians, who more properly are termed as maintenance men or trouble shooters.

With the scale of wages that usually holds good in most hotels, these good trouble shooters are really hard to find. But no matter what the scale of wages might be; no matter whether the hotel chief is obliged to put up with an inferior class of help; no matter what complaints are received, just or unjust, somehow or other, responsibility for all that happens is finally dumped at the chief engineer's door.

Every department in a hotel manages to keep on file at all times a fair supply of Morocco bound, gilt-edged excuses that are used when necessity demands to clear themselves.

The only recourse a chief has is to know that his plant is operating at top notch so as to be able to discount all complaints and lay them where they belong.

The above will serve to enlighten the layman regarding just what a hotel chief has to contend with.

Now to revert to the paramount question of water.

Any hotel executive is just as prone to call his chief on the carpet regarding excessive water bills as he is fuel bills. The city furnishing the water, allows to every hotel, a certain number of gallons of free water for sewage disposal. This free water is determined by the number of fixtures in the building.

Every gallon of water used over and above this free allotment must be paid for.

Naturally, the chief keeps as close a check upon water consumption as he does on fuel.

There is no one item used to such a great extent in a hotel as that of water. Steam generating, cooking, refrigeration, cleaning, dish washing, drinking, sanitation, fire protection, sewage disposal and in bathing are a few of its greatest uses.

Hundreds more could be tabulated if necessary. The human element that enters into its use is also varied: maids, cooks, laundry men, firemen, engineers, dish washers, scrubbers and last but *far from least, the guests.*

It is not possible to imagine the ignorance and carelessness of this human element. It is possible for the chief to keep a constant check on all hotel employes who have occasion to use water and he does so if he is earning his money and wishing to escape a monthly call down, but how, in the name of common sense, is a chief going to check on the water a *guest* uses, for it is through the guests that all large quantities of water are wasted. True, a guest pays for the conveniences of a room with bath (and sometimes dearly) but those conveniences do not include the wanton waste of water that ofttimes goes on.

There is a queer streak in the traveling public's makeup that shows the minute he enters his room. He feels that he can do almost anything within the law and it will be covered by the hotel bill. It's true. I have felt that way myself. There is the lady who talks over the phone to some social or business acquaintance while through the overflow of the tub in which she is drawing her bath, two or three hundred gallons of water flow to the sewer.

Then there is the man who lets the water in the lavatory during the ten minutes he uses to take his daily shave. It's just thoughtlessness I know but think what it means to a worrying chief downstairs.

Regarding those leaky water fixtures mentioned in the original article: In a hotel, say of 500 rooms, it is not possible for the maintenance men to inspect each room every day. Where we can enjoy the co-operation of the maids who care for the rooms, the total of leaky fixtures is kept to a minimum.

Where we cannot enjoy it, we always try to inspect a certain designated number of rooms at certain periods.

If a guest should find a leaky fixture that has inadequately been overlooked, amid the many duties assigned to the hotel engine room force, the chief would in most cases, consider it a favor if such a thing were reported at once, but just because one or two or for that matter three water fixtures are leaking, what justifies a guest in believing that the hotel power plant is not being operated efficiently?

In spite of all the things that daily try a hotel chief's patience, I like the game. There is no other calling in its line that offers such a diversified field for practical or technical experience or the study of human nature. As a gentleman once remarked: "Humans are funny critters."

J. W. SHAW.

Boilers Floating on the Line

I HAVE carefully read the interesting and instructive letter of Fred S. Rutledge in the Aug. 15 issue and while it describes some of his peculiar troubles, it does not show that there is any danger whatever in cutting in boilers when the pressures are not equal.

It calls attention, however, to another superstition harbored by some theoretical engineers to the effect that it is dangerous to leave one boiler of a battery floating on the line, when there is no fire under it. If trouble has ever been caused by such action, it is due to an imperfectly arranged system of piping and nothing else. My reason for this conclusion is as follows:

There are six boilers in my plant and during cold weather all are used except on Saturday and Sunday. On Friday night, one of the fires is allowed to go out, and usually the boiler is not cut out. Heat from the brick setting maintains part of the original pressure, and steam from the header does the rest. On Sunday night or Monday morning, a fire is built under the idle boiler and it goes into service automatically.

I understand perfectly the objections raised to this practice. It is claimed that it causes the top of the boiler to remain expanded by heat of the steam while

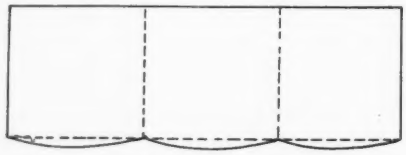
the lower part becomes cool, and contracts as a natural consequence. This causes unequal contraction, hence the boiler is badly strained, the shell is weakened, the tubes leak, etc.

Two of my boilers have been thus operated for more than a quarter of a century, while three others have stood it for 19 yr., and the other has survived for 8 yr. Not one of them has ever leaked or shown distress in any way. If it really does operate as theorists claim, how much longer will be required to demonstrate it?

W. H. WAKEMAN.

Oil in the Boiler

RECENTLY there occurred in this town a serious bag on a horizontal return tubular boiler as illustrated. This boiler was bagged down one inch the whole length of the shell except where the girth seam was. It was repaired by heating and driving back. I understand that this was caused by the plates not being kept clean in the oil separator, and the oil was not being separated from the steam. It passed on with the exhaust steam into the heating system and was returned with the condensation into the boiler. As the oil or its deposits settle on the shell exposed to the hot gases, and as the oil is a non-conductor of heat, the water cannot get at the heat to conduct it away, therefore the plate becomes overheated and bags. This shows that oil in the boiler is serious and when the fireman sees oil in his gage glass he should report to the engineer immediately.



RESULTS OF OIL IN BOILER

The plates in the oil separator should be boiled out with caustic soda at least every 3 mo.; it should be seen that the holes in the plates are open also.

If you get oil in the boiler get it out as soon as possible by boiling with soda ash and with the manhole open. I should use about 50 lb. and boil for three days if possible, then drain and wash well. After that use about 1 lb. soda ash per day for each boiler.

W. N. L.

Taking Chances

STATIONARY ENGINEERS are supposed to be among the most careful and painstaking of mechanics. They are usually held accountable for loss of life, by bureaus of licenses, and are also responsible to their employer for damage to property caused by negligence, or inattention to the machinery of which they are in charge; but there are men, who, while they would not cross a strange pasture after dark without a lantern, will assume charge of a strange plant, with only a most cursory examination, if any at all.

One cannot know the condition of a plant, especially if it is standing idle, with merely a superficial inspection. A man will go into a strange plant, say, on a Monday morning (I have done it myself) to start up, taking the chance that everything is in order. The engineer preceding you may have been disgruntled, or may have left under a cloud, so to speak, and not have taken much pains, if any, to leave the plant in shape for his successor. If he should chance to be there to show you over the plant, he might not take the trouble to point out all the imperfections.

The writer once took charge of a plant in a hospital in New York City and was shown two bags on the front sheet of one boiler, but nothing was said about the guards and bolts being burned off the handhole plates of the other three boilers.

Another time, the engineer of an apartment house had been discharged and I started there on a bitter cold day in February. The return trap was broken, and the returns were going to the sewer. The pipe from the return tank was under the floor and the cock was situated on the ground in front of the cleanout door. The last thing the engineer did before leaving was to close the cock, and cover it with ashes. I was 3 hr. locating the trouble, and getting radiators clear of water, in order to heat the house.

It is also necessary to inspect thoroughly a new plant. The carelessness of some contractors, or their men, is to be deplored. I once took charge of a new plant for a railway system in Maine. We had been running about a week, carrying 115 lb. of steam, when a leak developed in a screwed joint on an 8-in. steam line. The following Sunday we opened a flange union adjacent to the leak and the pipe fell apart at the leaky joint. The thread had entered the fitting only one and one-half threads!

In another case I was in charge of a new plant in a large loft building in New York. A leak developed in a "Vanstone" joint of a 12-in. pipe carrying 150 lb. of steam. Upon removing the magnesia covering from the flange, we found that three bolts had been left out of the joint, and the joint covered! It seems to me that such cases amount to criminal carelessness, and should be punishable. In the event of a serious accident, investigation might make it appear that the engineer in charge had left the bolts out, whereupon he might lose his certificate, as well as his job. A friend of mine, starting up a strange plant for the first time, in a hurry, lost a nut and ball off the governor; it fortunately happened to drop before the engine had made but a few revolutions, otherwise there might have been a chance for someone to get hurt.

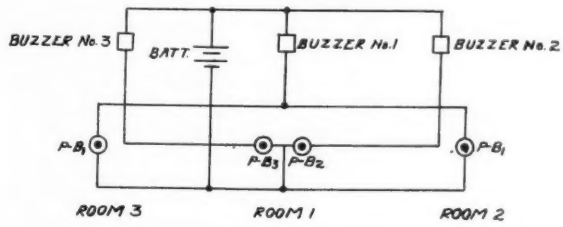
In a 5000-hp. plant there was a set of rules posted governing the watch engineers. Rule No. 1: Engineers will report for duty 15 min. before relieving time to make an inspection before relieving the watch. How much of an inspection could be made in 15 min.? Half of that time was spent in changing clothes, then to "inspect" 7 Corliss engines, 7 generators, 11 water-tube boilers, and race through 200 ft. of cellar to "inspect" the condensers and pumps before you could sign your relief's O. K.

We are constantly reading in the daily papers of boiler and flywheel explosions, bursting steam pipes, and other accidents, the result of which is nearly always loss of life, and destruction of property. An old adage is "Eternal vigilance is the price of safety." Let us be careful.

M. M. BROWN.

Buzzer Signal System

SOME TIME ago I was called upon to make an installation consisting of three buzzers and four push buttons so that the occupants of one room could signal the occupants of two other rooms and also permit the latter to acknowledge the signal.



THREE-ROOM SIGNAL SYSTEM

The apparatus was accordingly connected up as shown in the accompanying sketch which is self-explanatory. Two dry cells furnish the required electromotive force. With this arrangement, it will be seen, the occupant of room 1 may signal either room 2 or 3 by pushing either P-B_2 or P-B_3 while the occupants of rooms 2 and 3 may acknowledge the signal by pressing their respective push buttons.

JOHN C. KAHL.

Packing Kinks

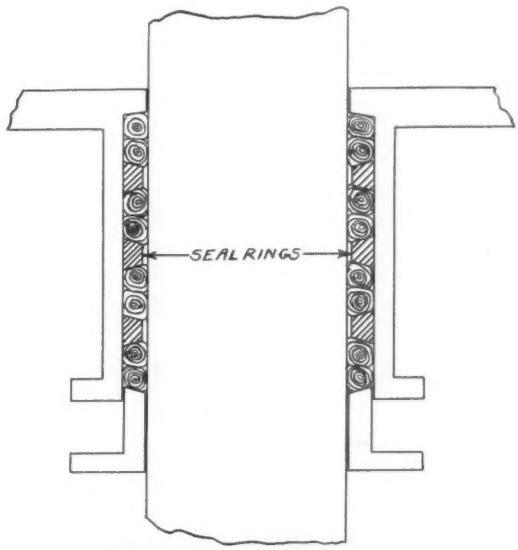
THAT THE packing problem is still with us is evidenced by the great variety that are daily offered to the power plant man. In my 10 yr. experience with hydraulic machinery of different kinds and pressures ranging from the ordinary tank to 4000 lb. per sq. in., I have tried many of the patent packings that have been highly recommended, with only indifferent results and have found that my own scheme gave about as good results, money considered, as anything else I had tried.

All are more or less familiar with the steam seal on valve stems, when a perfectly trued rod with annular grooves turned on it over a short space, passes through the box or snug fitting hole without other packing. The steam condensing in the grooves forms water which resists the passage of steam past the rod. This is also a common condition in the ring and plunger packed pump.

It was after my first experience with the ring and plunger pump that the idea occurred to me that the same principles might be utilized to advantage to help over difficulties in the packing of other machines of different types and I began to experiment, with the result that I finally had a very satisfactory scheme for packing and one that gave fine results.

The idea that soft fibrous packings are not suitable for high pressures has not been my experience, as I have used specially treated flax up to 4000 lb. and on rods up to 190 deg. with entirely satisfactory results. The ordinary jute or hemp so-called flax are better when boiled in a good mineral oil until they are thoroughly impregnated before using. The ends should be cut square and smooth with a sharp knife and taped to prevent unraveling, otherwise they may become frayed while shoving them to place with tools. They should be full length so that they will butt snugly together and have no gap at the joint.

If the clearance around the plunger is large, it is better to use some form of hard ring to prevent the soft packing being pulled or pressed through. If no other is at hand, a ring of hard duck that will just fit the space between the sides of the box and plunger or



METHOD OF PACKING PLUNGER

rod and center it, may be used. Following this, two rings of soft packing with joints broken should be put in and shoved home until they fit snugly and evenly. After these are in place a ring of hard duck about half the thickness of the regular packing and ⅛ in. smaller, with the sides preferably beveled inwards a little, if it is practicable to do so, is fitted tightly to the outside surface of the box and shoved to place. The ends of this should be lap jointed so that they may be fastened together, otherwise they may come apart while being shoved in and either make a poor seal or be difficult to get back together again. These rings may be made of standard hard duck ⅛ in. smaller than size of box and split in half to make two rings. Rings of hard and soft

packing should be so alternated as to form three water spaces if possible, then the balance should be filled with the soft packing until the box is full. It calls for a deep stuffing-box which is an item well worth considering when buying equipment. The shallow boxes mean incessant tightening with consequent wear on packing and plunger, to say nothing of the friction loss. Should it be necessary to use a lubricant, let them leak a little, clean water is a good lubricant and you have the additional satisfaction of knowing they are not too tight, thus wasting steam. Heavy oils and grease should not be used. I have seen large engines drop the pressure as much as 10 lb. from the application of too much heavy oil on plungers.

HOMER JOHNSON.

Boiler Kinks; Handy Oil Can

A FRIEND told me about the labor saving idea shown in Fig. 1. The ash pit had brickwork built in as shown at A. This reduced the ash removing labor considerably, doing away with much of the back breaking back hoeing. At B is shown an idea for installing and protecting blowoff pipes.

At one time a man had considerable trouble by water going over with the steam, from a small boiler, 48 in. in diameter; the trouble was overcome by attaching a short nipple and a cap to the steam outlet, as shown at C; ⅛-in. holes were drilled all around the cap and over the bottom. This proved a perfect cure.

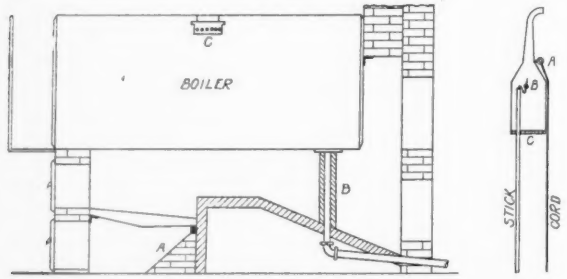


FIG. 1. KINKS APPLIED TO BOILER AND SETTING
FIG. 2. CAN USED FOR OILING LINE SHAFT BEARINGS

A handy kink is shown in Fig. 2. Solder two small rings onto an oil can as at A B. To A attach a cord. Have a long stick with a hook in one end to use in B. By raising the oil can and pulling down on the cord, shafting can be oiled without the use of a ladder. If a weight is attached to the bottom of the can, at C, it will always remain upright on the stick even when empty. A flat piece of metal can be soldered on as a weight.

JAMES E. NOBLE.

A Cheap Homemade Dust Collector

IN A LARGE wet wash laundry where many dirty clothes are sorted during a day's run, they are thrown on a table; in doing this much dust is stirred up which is not very sanitary as far as the health of the employes doing the work is concerned.

To remedy this condition, a table was built, the top of which was made of maple flooring drilled full of ½-in. holes, as shown in Fig. 1. The tops of these holes were countersunk, as shown in Fig. 2. The sides and ends below the table top are inclosed to the floor. Into one end of the table a 15-in. suction pipe was placed, as shown in Fig. 2. This pipe is connected to a fan which draws the dust through the holes in the table and discharges it above the roof. Since installing this table and fan, there is little dust to be seen when shaking out the clothes and sorting them.

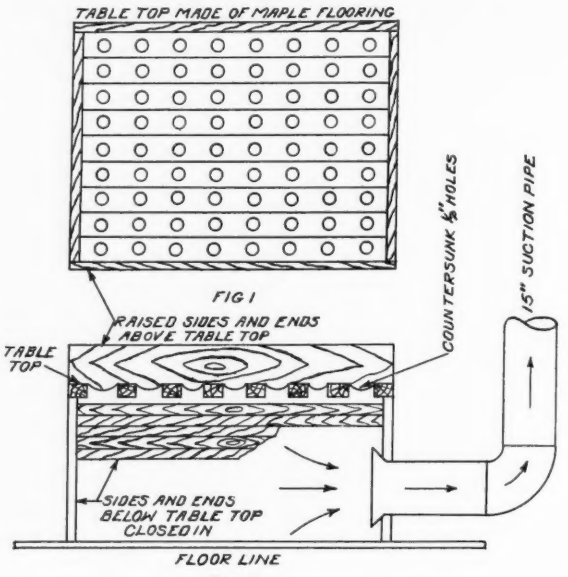


FIG. 1. PLAN VIEW OF DUST COLLECTING TABLE
FIG. 2. SIDE ELEVATION OF TABLE

I thought this kink would be of interest to some other reader who may be called upon to devise some method of collecting dust from some material that is made in the plant of which he is engineer.

H. A. JAHNKE.

When Rusted On

I WAS READING an article relative to the adhesion between two pieces of metal, when caused by rust. It was stated that whenever two parts of iron or steel have become rusted firmly together, they may be separated by soaking them for several hours in a mixture of ⅓ lubricating oil and ⅔ kerosene.

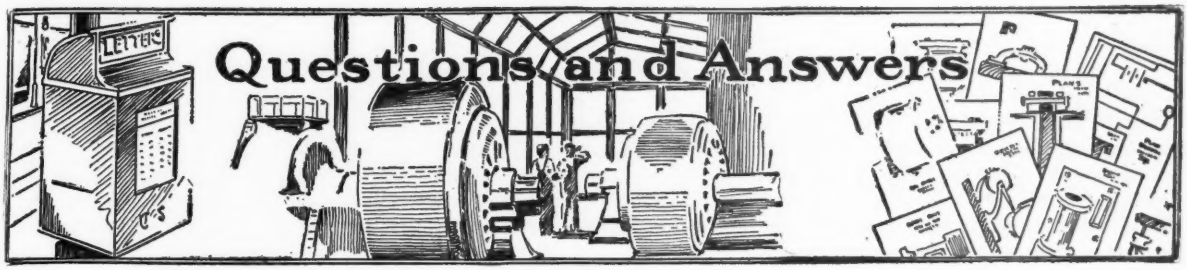
I mentioned this "kink" to an old engineer and he said: "Turpentine is better."

I pass the information along, believing that at some time some of us will meet up with the condition and have a remedy.

J. B. DILLON.

COMBINED STATEMENT of Utah Power and Light Co., the Western Colorado Power Co. and Utah Light and Traction Co. for the year ended last Dec. 31, shows a surplus after charges, taxes and depreciation of $974,489, compared with $1,012,152 in the previous year. Net earnings, after taxes, amounted to $4,086,694, against $3,771,039.

EXPERIMENTS have shown that preheating the air for boiler furnaces results in higher furnace temperature and lower chimney gas temperature due to more rapid transfer of heat to the boiler heating surfaces.



Longest High Tension Span

I WOULD like to have the opinion of the readers of Power Plant Engineering as to what is the length of the longest span for high tension transmission in the United States. H. A. G.

Smoke Abatement

I WOULD appreciate having the suggestions of the readers of Power Plant Engineering as to how I can combat the formation of smoke in my furnaces. We are having complaints on account of this nuisance and I would like to clear up the situation. E. H. S.

Quiz

WILL THE readers of Power Plant Engineering give me the answers to the examination questions given herewith?

1. Give formula for figuring stretch of plate in a sag, that is, thickness of sheet at center of sag.
2. Where are horseshoe nails used on a B. & W. boiler?
3. Why do the Massachusetts rules allow 9000 lb. per sq. in. on a brace over 1¼' diam. or equivalent and but 8000 lb. per sq. in. on one less than 1¼ diam.?
4. How would you take a pop safety valve apart without taking tension off spring?
5. A. B. & W. boiler, three-drum type, suddenly lost the water in the center drum, but it was at the proper height in the two outside drums. What was the cause?
6. In laying out the braces on a flat head, what, under good practice, would be the maximum allowable fiber stress in the plate itself and how would you determine it?
7. Describe a Smith setting and how it operates.
8. Inspecting a Manning boiler, what calculations would you make in figuring the safe working pressure?
9. What is the objection to copper steam pipes when they are used almost exclusively at sea?
10. How do you secure the factor of safety when figuring on a flywheel? J. A. C.

How Should This Boiler Be Fired?

I READ with much interest A. C. Waldron's article on "Firing Boiler Furnaces." I am firing on a steamship that has one Scotch type drum boiler which furnishes steam at 45 lb. per sq. in. to a beam engine having a 6-ft. stroke.

The boiler is a hard steamer and with a poor quality of coal it is impossible to maintain over 30 lb. pressure. I have tried all the tricks of firing that I knew and the only way I could get any good results with fine coal was to spread lightly and often all over the fire and then break it up with the hook and haul it to the front about every third fire. With lump coal, I can load the fire heavy near the doors and light behind. The fire acts peculiarly in some respects. There are two doors to the furnace and it is divided by a water leg. One side of the fire will burn bright and apparently be doing all the work while the other side will die down in a few minutes unless it is kept stirred up with the hook or slice-bar. I have tried everything I know of to remedy this, but do not seem to strike the right thing. I have carried a heavy fire on one grate so as to get more draft on the other, but that seems to make no difference.

If any one of the readers of Power Plant Engineering can give me any advice as to how to overcome this trouble, I shall be grateful. R. F. L.

Journeymen Electricians' Examination

THE FOLLOWING set of questions were taken from a journeymen electricians' examination. How would you answer them?

1. Draw a diagram of a set of 3-way switches with 4 lights.
2. How should the wiring be done in a moving picture booth?
3. Draw a return call bell system using only three wires.
4. How would you test for a ground in a residence wired with knobs and tubes?
5. In knob and tube wiring:
   (a) What distance must be maintained between wires without extra insulation?
   (b) Where are 4-in. tubes required?
6. How would you support heavy wires in a vertical iron conduit system?
7. Why should all wires of an alternating current circuit be placed in the same iron conduit?
8. What is the greatest distance allowed for spacing knobs?
9. What are the requirements pertaining to the installation of a flush switch box?
10. When should canopies be insulated?
11. How many wall plugs should be placed in one circuit?
12. Where are mainline switches required to be installed on all services?
13. What kind of a cord should be used for portable incandescent lamps and fractional hp. motors?
14. When should porcelain sockets be used?
15. Explain the effect and danger of taping an unsoldered joint.
16. How many sockets may be connected to a branch circuit in a residence?

17. How should knob and tube wiring be carried through a brick wall?

18. Show by diagram the connection of a three-wire, three-phase meter loop.

19. In wiring a house of seventeen 50-w. light outlets, five switches and two receptacles for lights and one receptacle for iron, how many circuits would be required?

20.. Why is it not permissible to pull in the wire at the time the conduit is installed in concealed work?

21. Show by diagram the connections of a three-wire, single-phase meter loop. A. G. M.

Ohm's Law

CONCERNING the comment of Mr. Row and editor's note under the caption "Ohm's Law" on page 778 of the Aug. 1 issue, I feel that additional comment on this subject may serve to make the relation of the ohm, ampere and volt more clear.

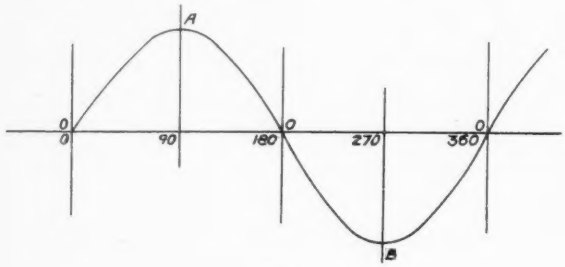


FIG. 1

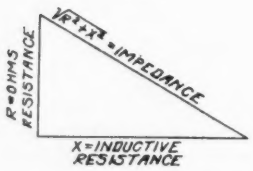


FIG. 2

FIG. 1. A.C. CURRENT CURVE

FIG. 2. VECTOR DIAGRAM SHOWING OHMS AND INDUCTIVE RESISTANCE IN AN A.C. CIRCUIT

There has been much discussion in the past by physicists when meeting in international conferences, as to which two units should be considered as standards. In 1908, an international commission at London decided that the ohm and ampere should be the first and second respectively, and that the voltage should be determined from the ampere and the ohm by Ohm's Law.

For practical purposes, as suggested in the editor's note referred to, any two can be used as standards. Since the criterion for a working standard is its reproducibility and its permanence, the choice of the units to be made standards will be determined thereby. Of course there are other factors which influence the selection of these units; thus, the question of which two units to use as standards will be determined largely by the possibility of constructing suitable standards.

Either the Clark or Weston cell may be used as a standard of voltage. These cells when properly made of pure materials give a convenient and satisfactory means of measuring differences of potential. By the use of the potentiometer, a wide range of potentials may be compared.

The primary standard of resistance is the resistance offered by a column of mercury of constant cross-section, whose dimensions have been carefully defined. Standard resistances, made of material whose characteristics are well known, are used as working standards having been checked against the mercury standard.

The primary standard for current depends upon the weight of silver deposited from a silver nitrate solution in a given length of time. The apparatus for doing this is called the silver voltameter.

While the silver voltameter will give very accurate results, yet because of its limitations, the standard cell and the standard resistances have become the two standards usually found in most laboratories, for calibration purposes.

K. B. MCEACHRON.

OHM'S LAW as defined on page 778 of the Aug. 1 issue: I equals E divided by R; where I is the intensity of the current in amperes, E, the electromotive force in volts, and R the resistance in ohms, is correct and essential but it should be remembered that it is applicable only when dealing with direct current.

In the transmission of alternating current the same resistance is met with as in direct current, that is, the resistance R as mentioned in Ohm's law. This is spoken of as the ohmic resistance, to distinguish it from another opposing force which is known as inductive resistance. In direct current, only the ohmic resistance is met with, and is therefore spoken of simply as the resistance.

In alternating current, there is at every reversal of the current a force tending to prevent this reversal. This force, in mechanics, is known as inertia, which is that property preventing a body moving, from coming to rest, or a body at rest from moving except when acted upon by an external force. This same property is present in electricity as well as in the other physical phenomena of nature such as light, heat and sound. At every reversal of the current, it meets with this opposing force, which might well be called electrical inertia, but which instead, is known as inductive resistance. As this is in opposition to the change in velocity of motion, rather than to the motion itself, its greatest effect will be at the point where the current is zero, as at this point the change in velocity is most abrupt, which may be seen by reference to Fig. 1. It will also be seen that when the current is at a maximum as at A or B, there will be no inductive resistance, since there is, at these points, no change in the current velocity. It is therefore evident that the inductive resistance is 90 deg. in advance of the current. As the ohmic resistance is opposing the flow of current rather than its change of intensity, it will be greater when the current is greatest, and will be nil when the current is changing its direction, or is at the zero point. In other words, it will be in step with the current. Since the inductive resistance is 90 deg. ahead of the current, it will also form a 90 deg. angle with the ohmic resistance, which is in step with the current.

This alternating current is then found to be opposed by two resistances, which are at right angles to each other. The resultant of these two resistances, Fig. 2. or the impedance, will be the hypothenuse of the right triangle whose legs are composed of the ohmic, and the inductive resistances, respectively.

Then to write Ohm's Law for alternating current we have:

$I = E \div \sqrt{R^2 + X^2}$ where X is the inductive resistance.

J. M. Row.

Feed-Water Heaters

Referring to A. C. B.'s note in the Aug. 1 issue, I would advise that if a small amount of steam is going to waste and a feed temperature of only 150 deg. is being secured with all the steam passing through the heater, Mr. B.'s first move to increase the efficiency of his layout should be to investigate the heater construction itself, for it is evident that the water is not being properly heated by the steam that is available. With plenty of exhaust steam, a temperature of at least 200 deg. or even 210 deg. should be obtainable. The 150 deg. temperature represents a preventable waste of 5 per cent of the coal bill, which would probably figure to be quite an item.

Mr. B. should investigate the heater inside to see whether the water is being properly broken up by the baffle pans and to see that it is evenly distributed over all the available baffle surface. It may be that these pans are out of plumb and all the water is passing over one side. Try running cold water through the apparatus while it is open for inspection.

Then some provision should be made for venting out the air which is driven off the water. Mr. B.'s drawing does not show any such vent connection. It should be at least a 1-in. line tapped into the heater shell about a foot above the water line, and running free to atmosphere for taking off air and gases which might otherwise air-log the apparatus.

It may be that the baffle pans are all scaled up which may result in poor distribution of the water.

Again it may be that the steam is allowed to make a short cut from the inlet to the outlet in the shortest possible route instead of being diverted to all parts of the heating chamber. A baffle should be placed near the steam inlet to shunt the steam into the back of the heater section.

The location of the back pressure valve suggested seems to be all right, though operating the engines and pumps under a back pressure will naturally cut down their efficiency or increase the steam consumption and if it is possible to utilize the steam and heat the water without adding this back pressure it is certainly advisable to do so.

M. A. Saller.

Scored Pump Cylinders

Replying to E. G. M.'s article on page 824 of the Aug. 15 issue of Power Plant Engineering, I do not think 30-ft. piston speed per minute is at all excessive for a 10 by 12-in. single pump at 100 lb. pressure; but the 200 deg. temperature of the water supplied to the pump leads me to believe that he is using an open heater. Even though the water may be clear and free from scale, if the bottom of the heater is filled with a coke bed for filtering purposes, it would appear that the strainer over the end of the suction pipe may be worn through, or that the heater may have been pumped dry occasionally and drawn much of the fine coke or other gritty substance from the heater into the pump, which after cutting and scoring the cylinder is forced up through the valves and discharged into the boiler, where it is lost track of.

After the heater has been supplied with water to fill it up to the float which controls the supply valve, the flow of gritty substance from the heater into the suction pipe would cease until the heater became dry again. The sudden excess draft as the pipe takes in air or vapor and water is what catches the grit. Then, too, if the returns from a heating system come back to the open heater or even a tank from which the pump gets its supply, there may be some scale from the inside of the pipes coming back with the returns into the tank or heater, which have not been discovered.

If there are any steam traps near, opening up one would show how much scale accumulated in the trap and calculation could then be made as to the amount that could be expected to return from the system. If a receiver tank is used, there should be some scale lodged near the ends or corners of the tank. If any new piping was added to the plant, or radiators through which steam or condensate passed to the heater or receiver, there would be enough scale and grit or even pipe die chips in the pipe to cause such trouble unless precaution was taken to blow out the pipes with high steam pressure to clear out the grit or sand, which gets in when handling before the pipe is put in service. The fact that the pump had a new sleeve lining put in a year ago, and was a new pump 3 yr. ago, looks as if new sleeve linings were needed every 2 yr. This, of course, is excessive wear and expense.

The lining which ran only one year would appear to be of soft or inferior brass instead of hard bronze lining. If this was so, the use of a hard hot water packing without a lubricating ring between the hard rings would cause the cylinder lining to become worn and scored. When this scoring has once occurred, the packing will wear out very rapidly thereafter and have to be renewed at frequent intervals. If the pump is accustomed to handling feed water at a temperature of 200 deg. with hot water packing and the feed water temperature drops lower, which it often does with an open heater or receiver tank where make-up water has to be added to keep up the supply, then the hot water packing becomes hard again. This is when a lubricated ring is a benefit. The hot water packing is generally rockhard until the hot water strikes it and softens it. It is not a good packing to use where there is any cold water to pass through the pump even though the temperature of the water is 100 deg.; it is too cold to keep the packing soft enough to be serviceable. If this is the case, the minimum and maximum temperatures of the water should be found and a packing used suitable for both hot and cold water, which any packing manufacturer will furnish. (I use Tuck's square hydraulic for hot and cold water.) Cold water packing will soften up when in contact with hot water and soon wear out, but should not score the cylinder.

Square flax will not wear long against pressure and will, unless lubricated, cause scoring in time on soft brass linings. I am inclined to believe that the scoring is caused by grit in the feed water or getting into the pump intermittently. The sleeves should be filed out and scraped smooth if it is not possible to have them bored out.

Fitting the piston of cast iron with snap packing rings has been tried before, but as far as I can learn is not a success on account of wear and grit in the supply water, though some jet condensers are equipped with expansion packing rings on the water end, made in segments of brass and held out by springs. But jet condensers only pump against atmospheric pressure.

A plunger pump of the inside plunger type has a contraction or partition ring sleeve through which the plunger passes. Being closely fitted, it requires no packing other than the water passing through between the piston and ring sleeve. The sleeve is bolted to the partition and when worn can be removed and a new one put in. These plunger pumps are used against presures of 100 lb., but on starting, unless the water flows to the pump, generally require priming, where a packed piston pump does not. Higher pressure plunger pumps are generally outside packed, using fibrous packing, square flax or specially lubricated packing, according to the pressure against which the pump is working. The built-up metal piston with snap rings would cause excessive wear without lubrication and the time the pump would be out of service while the cylinder was being rebored and new snap rings fitted, would be considerable. The cost of one such job would pay for a lot of fibrous packing and if a metal snap ring broke, it would put the pump out of service in short order and score the sleeve lining worse where fibre packing would do only slight damage, if any.

If iron pistons were successful all the pump manufacturers would have equipped their pumps with them before now.

I would advise a careful search for above mentioned troubles and remove them as far as possible. Then consult the packing agent if he is one of experience. He can give you a packing that will give better service. But the sleeves must be smoothed up somewhat, and the agent must know the two extremes of temperatures of the feed water. There is much packing on the market, made from materials available during the war period, which do not give the service as before; but packing made since then is even better, due to the cheap market price of rubber. R. A. CULTRA.

Inductive and Capacity Reactance

WILL YOU kindly explain the action of a condenser in offsetting the effect of self-induction? In which part of the circuit is it connected? E. M. C.

A. In an alternating current circuit in which there is inductive reactance, the current lags behind the voltage, while in a circuit where there is only capacity reactance, the current leads the voltage. In a current then where both are present, the effect of one would tend to counteract that of the other.

To obtain a circuit where the current is in phase with the voltage or, in other words, where the power factor is 100 per cent, the inductive and capacity reactances must be exactly equal. Inductive reactance is equal to $6.28 \times f \times L$, where f is the frequency and L is the inductance in henrys. Capacity reactance is equal to $1 \div (6.28 \times f \times C)$, where C is the capacity in farads. Inductive reactance is always in series in the circuit and capacity reactance to offset effects of inductive reactance is in parallel.

Work of Expansion*

HOW DOES the work developed by a given volume of air during adiabatic expansion compare with that developed by steam expanding through the same pressure drop and under the same conditions? What is the method of calculating the difference?

2. In air compression, is the same quantity of heat given up by the air during the second rise of, say, 50 lb. per sq. in. as was given up during the first rise of 50 lb. per sq. in.? J. E. K.

ANSWERS

IN COMPARING the work developed by the expansion of steam and of air, we will assume that in both cases the expansion is adiabatic, that is, no heat is taken in or given out during the process. We will assume also that expansion takes place from an initial pressure of 100 lb. absolute to atmospheric pressure, or 14.7 lb. per sq. in.

For saturated steam the work,

$$W = J\,(xr + q - x_2r_2 - q_2)$$

where J is the mechanical equivalent of heat, x is the quality of the steam, r is the latent heat of evaporation and q is the heat of the liquid.

The subscript 2, indicates conditions at the final state.

First it is necessary to find the final quality, x_2. This can be found from the entropy equation,

$$S_1 + x_1r_1 \div T_1 = S_2 + x_2r_2 + T_2$$

where S is the entropy of the liquid and $r \div T_1$ that of the vapor.

We will assume $x = 1.00$.

All the other values except x_2 can be obtained from the steam table. Substituting these values, we get

$$1.6020 = 0.3118 + x_2 \times 1.7565$$

from which, $x = 0.735$.

Going back to the first equation and substituting the required values from the steam tables, we get

$W = 778\ (1186.3 - 0.735 \times 970.4 - 180)$, which reduces to

$W = 227{,}500$ ft. lb., which is the work done per pound of steam. As the density of steam at 100 lb. pressure is 0.2258, the work done per cubic foot would be

$$W = 227{,}500 \times 0.2258 = 51{,}300 \text{ ft. lb.}$$

The equation for the work developed by the adiabatic expansion of air is

$$W = p_1 V_1 \div (1.4 - 1)\,[1 - (p_2 \div p_1)^{(1.4-1) \div 1.4}]$$

where 1.4 is the ratio of the specific heats for air. Substituting our values in this equation, we get

$$W = 144 \times 100 \times 1 \div 0.4\,[1 - (100 \div 14.7)^{.285}]$$

from which $W = 26{,}450$ ft. lb.

The minus sign indicates simply that the air is doing work instead of work being done on the air.

It will be seen from this, therefore, that steam does more work in expanding between two given pressures than does air.

2. For adiabatic expansion

$$p_1^{(1.4-1) \div 1.4} \div T_1 = p_2^{(1.4-1) \div 1.4} \div T_2$$

From this equation, knowing the initial and final pressures, and the initial temperature, we can obtain the final temperature. We will suppose that the first increase of pressure of 50 lb. is from 15 lb. to 65 lb. absolute. Solving this equation, we get

$$T_2 = 1.521 \times 520 = 790 \text{ deg. abs.}$$

$$\text{or } t_2 = 790 - 460 \div 330 \text{ deg. F.}$$

If now we cool the air to the initial pressure, and again raise its pressure 50 lb. to 115 lb. abs., we get

$$T_3 = 1.169 \times 520 = 608 \text{ deg. abs.}$$

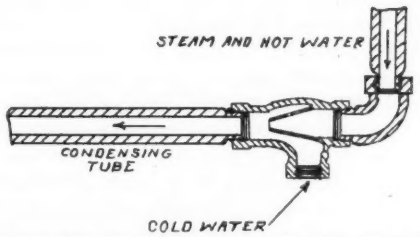
and $t_3 = 608 - 460 = 148$ deg. abs.

From these equations, it is evident then that the first rise of 50 lb. entails a much greater rise in temperature than does the second pressure increase. The final temperature of compression depends upon the ratio of compression rather than upon the absolute rise. As, for instance, in increasing the pressure from 15 to 65 lb. you are increasing the pressure 4.34 times, whereas in compressing from 65 to 115 lb. you are increasing the pressure by only 1.77 times.

Hot and Cold Water Mixer

How CAN a nozzle be made to place on the end of a steam and water line (return from traps or heating system) that empties into a rather cool tank, so as to utilize the heat and at the same time make a minimum of noise?

H. W.



SIMPLE SUCTION TEE FOR MIXING HOT AND COLD WATER

A. You can probably get the results you desire by the use of a suction tee, the outlet being extended 2 or 3 ft., so as to give time for the steam to be condensed by the water surrounding it.

Feed Water Analysis

HEREWITH IS a copy of an analysis of the water taken from an artesian well at this place, which has been pumped for 30 yr. Will you give me your opinion as to the quality of this water for boiler feed purposes?

WATER ANALYSIS

Carbonate of lime	16.2
Carbonate of magnesia	10.7
Carbonate of iron	5.0
Sulphate of potash	43.1
Sulphate of soda	1.4
Sodium chloride	107.2
Carbonate of soda	407.0
Silica	40.0
	630.6

Water shows faint traces of nitrates.

A. In our opinion, this water is not suitable for boiler feed purposes. We do not know of any process of treatment which would be commercial and which would put it in shape for such use. With a density of 628.6 grains per gallon to begin with, the concentration has already reached the ordinarily accepted foaming point. With some types of boilers it might be possible to run for two or three hours at rating without blowing down. Ordinarily this water would cause foaming at boiler rating in less than an hour.

Length of Rivet for Given Length Grip

I WOULD like to get a rule for finding the length of rivets, both round head and countersunk, that would be required for riveting lap joints on various thicknesses of sheet metal plates. F. N. V.

Lengths of Rivets With Various Grips for Boiler Plate

Grip in inches	Round-Head Rivets: Diam. in in. 1/2	5/8	3/4	7/8	1	Countersunk-Head Rivets: Diam. in in. 1/2	5/8	3/4	7/8	1
	Length in in.					Length in in.				
1	2	2-1/4	2-3/8	2-1/2	2-5/8	1-5/8	1-3/4	1-3/4	1-7/8	1-7/8
1-1/4	2-1/4	2-1/2	2-5/8	2-3/4	2-7/8	1-7/8	2	2	2-1/8	2-1/8
1-1/2	2-5/8	2-7/8	3	3-1/8	3-1/4	2-1/8	2-1/4	2-3/8	2-3/8	2-1/2
1-3/4	2-7/8	3-1/8	3-1/4	3-3/8	3-1/2	2-3/8	2-1/2	2-5/8	2-5/8	2-3/4
2	3-1/8	3-3/8	3-1/2	3-5/8	3-3/4	2-5/8	2-3/4	2-7/8	2-7/8	3
2-1/4	3-3/8	3-5/8	3-3/4	3-7/8	4	2-7/8	3	3-1/8	3-1/8	3-1/4
2-1/2	3-5/8	3-7/8	4	4-1/8	4-1/4	3-1/8	3-1/4	3-3/8	3-3/8	3-1/2
2-3/4	3-7/8	4-1/8	4-1/4	4-3/8	4-1/2	3-3/8	3-1/2	3-5/8	3-5/8	3-3/4
3	4-1/4	4-1/2	4-5/8	4-3/4	4-7/8	3-5/8	3-7/8	3-7/8	4	4-1/8
3-1/4	4-1/2	4-3/4	4-7/8	5	5-1/8	4	4-1/8	4-1/8	4-1/4	4-3/8
3-1/2	4-3/4	5	5-1/8	5-1/4	5-3/8	4-1/4	4-3/8	4-3/8	4-1/2	4-5/8
3-3/4	5	5-1/4	5-3/8	5-1/2	5-5/8	4-1/2	4-5/8	4-5/8	4-3/4	4-7/8
4	5-1/4	5-1/2	5-5/8	5-3/4	5-7/8	4-3/4	4-7/8	4-7/8	5	5-1/8
4-1/2	5-3/4	6	6-1/4	6-3/8	6-1/2	5-1/4	5-3/8	5-1/2	5-1/2	5-5/8
5	6-3/8	6-5/8	6-3/4	6-7/8	7	5-7/8	6	6	6	6-1/8

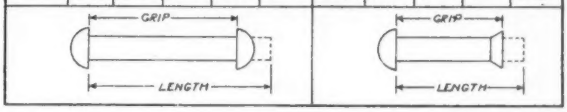


TABLE SHOWING LENGTH OF RIVET FOR ANY GIVEN LENGTH OF GRIP

A. The accompanying table taken from Marks Mechanical Engineers' Handbook will answer your question. There is no definite nor established rule for finding the length of the rivets but it will be found that this table represents good practice.

Condensing Water Required

WILL YOU kindly inform me as to how to compute the necessary amount of cooling water required to condense one pound of steam at 6 lb. gage pressure, the cooling water temperature being 84 deg. F.? G. G.

A. In regard to the cooling water required for your condenser, Kent gives the following formula for jet condensers:

$$Q = (1114 + 0.3 \times T - T_2) \div (T_2 - T_0)$$

where T is the temperature of the steam at the terminal pressure in the cylinder, T_2 is the temperature in the hot well and T_0 is the temperature of the cooling water.

For 6 lb. gage the value of T from steam tables would be 229.6 deg., the value of T_2 for atmospheric pressure would be 212 deg. and the value of T_0 is, of course, 84 deg.

Substituting in this equation, we have

$$Q = (1114 + 0.3 \times 229.5 - 212) \div (212 - 84)$$

which works out to 7.58 lb. water required per pound of steam condensed.

Correction Note

IN QUESTION 33 of Engineers' Examination Questions on page 587 of the June 1 issue, in figuring the size of a boiler feed pump, it is stated that the assumed speed was 50 strokes per minute whereas the assumption was 150 strokes per minute and the problem was worked on that basis.

The length of stroke which was assumed equal to twice the diameter should have been 5 in. instead of 6½ in. as stated.

POWER PLANT ENGINEERING

Trade-Mark, Reg. U. S. Pat. Office

Issued the 1st and 15th of each month. Established over 25 yr.

Published by the TECHNICAL PUBLISHING CO.
537 South Dearborn Street, Chicago.
New York Office, 150 Nassau St.

Subscription price $2.00 a year in postal zones 1, 2, 3, 4 and 5, which include all postoffices within a distance of 1400 miles from Chicago.

Subscription price $2.50 a year in postal zones 6, 7 and 8, which include all postoffices more than 1400 miles from Chicago.

Copies, current issue, 15 cents; back numbers, 25 cents.

Notify us at once of any change of address, giving the old and the new address, so that your paper may always reach you promptly.

Copyright, 1921, by Technical Publishing Co.

Entered as second class matter May 1, 1908, at the Post Office at Chicago, Illinois, under the act of March 3, 1879.

Member, Associated Business Papers.
Member, Audit Bureau of Circulations.

Circulation of this issue 20,750.

CONTENTS

Meeting Power Needs of Growing Factory. By Frank C. Vogan. Illustrated 885
Europe Enters Period of Steady Development of Power Industry. By L. W. Alwyn-Schmidt....892
Impractical Boiler Connections. By George C. Stierhoff. Illustrated 895
Leakage in Surface Condensers. By George C. Cook....896
High Cost of Sagging Insulation. By S. Roland Hall. Illustrated 897
Constructing a Sheet Metal Elbow. By F. Webster. Illustrated 898
Diesel Engine Practice—I. By A. H. Pritchard. Illustrated 901
Valve Disc Comes Off 903
Switchboards for Industrial Plants. By Victor H. Todd. Illustrated 904
Efficiency of Adjustable Speed Motors. By R. W. Owens. Illustrated 908
Hoisting and Conveying. Illustrated 912
Vacation Adventures and Observations. By Operator. Illustrated 915
Judging Efficiency by the System of Maintenance Employed. By George Talcott Ingersoll....915
Some Recent Experiments on Lubrication. By J. H. Blakey 917
Electrically Heated Steam Boilers. By Eric A. Lof. Illustrated 919
Temperature Regulator Chart. Illustrated 920
Price Deflation 921
Regarding Oil Shale 921
Letters Direct from the Plant: Grounded Lines; Motor Speed. Water for Hotel. Boilers Floating on the Line. Oil in the Boiler. Taking Chances. Illustrated.922
Successful Kinks from the Power Plant: Buzzer Signal System. Packing Kinks. Boiler Kinks; Handy Oil Can. A Cheap Homemade Dust Collector. When Rusted on. Illustrated 925
Questions and Answers: Longest High Tension Span. Smoke Abatement. Quiz. How Should This Boiler Be Fired? Journeymen Electricians' Examination. Ohm's Law. Feed-Water Heater. Scored Pump Cylinders. Inductive and Capacity Reactance. Work of Expansion. Hot and Cold Water Mixer. Feed Water Analysis. Length of Rivet for Given Length Grip. Condensing Water Required. Illustrated....923
Editorial: Safe Investments. Meeting Future Power Requirements. Coal Production 932
Life as a Business Proposition. By Dr. Frank Crane....933
A New Type Underfeed Stoker. Illustrated 934
News Notes 936
Books and Catalogs 936

Safe Investments

So many people have been induced to part with their Liberty bonds in exchange for worthless certificates of stock by swindlers who prey on those inexperienced in investing that it is worth while emphasizing the first requirement of a good investment. The principal must be safe.

Liberty bonds have shrunk in market value. So have all other bonds, and the loss has been no greater to owners of Liberty bonds than to those who owned other bonds; not nearly so great as to those who owned industrial stocks. Also, the interest on Liberty bonds has been and always will be paid promptly when due, while interest on other bonds has been delayed and many industrial stocks have lowered their dividend or ceased paying altogether.

Good bonds, of railroads, industrial companies or public utilities sold by reliable bond houses will seldom lose greatly in value, but stocks of any kind are not a good investment for moderate savings. There is always the gamble of loss in value from bad business conditions, which, for the small investor, more than offsets the possibility of gain by increase in value of the stock.

Government securities—Liberty bonds, treasury certificates or savings stamps—are the safest investment that can be bought, are free from possibility of any large change in value, will be paid at maturity, and there can be no loss of interest. It is interestiug to note that the Federation of Labor has passed a resolution warning its members against buying or trading for worthless stocks and securities, and urging government to continue the issue of treasury securities and workers to buy them regularly.

This is good advice. Both that to save and accumulate a surplus, and that to put it into *safe* investments. Nobody can get ahead except by saving; and a promise of big interest or dividends is of no advantage if the principal is in danger of being lost. Save, and keep the savings safe is the only sure method to achieve prosperity and comfort in the afternoon of life.

Meeting Future Power Requirements

The same sort of foresight which enables great captains of industry to plan expansion projects of corporations under their control is also of value to the designing engineer of a power plant project. The ability to predict future requirements or to predict possibilities for expansion is what, in many instances, gives one man a superior rating over that of another. To all appearances, the design and construction of one plant may seem equally as good as that of another of the same type and capacity, yet one is superior because of the provisions made to accommodate future growth. Sometimes such provisions consist merely in providing a more or less temporary wall, at others, it may consist in an intelligent selection of machinery so as to avoid the necessity for selling or scrapping when replacement by larger apparatus becomes necessary.

An industrial plant, if in a healthy condition, is bound to grow. In some cases, such growth is more rapid than in others; but in any case, unless adequate provisions are made in the original design of the power plant to take

care of future power requirements, an unwarranted expenditure of money may be necessary later on.

The incorporation of suitable provisions to meet future requirements will no doubt involve a slightly greater expense at the beginning, but such expense will always be offset by the amount saved when the time for expansion arrives. To neglect this feature in the design of any plant is not only a short-sighted policy, but a costly one as well.

It is often impossible to foresee with any degree of certainty the expansion to which a plant will be subjected. In such instances, it is, of course, inadvisable to set aside a certain amount of space or to invest money in oversized equipment with the intention of utilizing such space or operating such equipment at full capacity later on. This is not necessary nor advisable except in cases where it is extremely evident that the equipment will be available for use within a comparatively short time. What is necessary, however, is the intelligent selection of equipment and planning of buildings so that future additions may be made with a minimum of expense. Buy standard equipment so that if it becomes necessary, a machine from one part of the plant can be replaced by a larger or smaller machine from another part of the plant. In purchasing each piece of equipment, the engineer designing the plant will do well to ask himself, "Will this equipment be of use to me when I increase the capacity of my plant?"

An excellent example of a plant which was subjected to rapid expansion and the manner in which the increasing power requirements were met, is described elsewhere in this issue by Frank C. Vogan. While the growth of this plant, due to war conditions, was extremely rapid, it was by no means uncommon and is typical of the growth which characterized hundreds of industrial plants throughout the country during the past 6 yr. Some of these plants were in better shape to meet expansion requirements when the time arrived than others, and as a consequence they were the gainers.

While future growth among industrial plants throughout the country will probably not proceed with the same degree of rapidity as was the case during the period through which we have just passed, it will be well to profit by experience and be prepared to meet the other more moderate growth of plants that is certain to follow.

Coal Production

For 1921, up to Aug. 20, the bituminous coal mined in this country was 83,000,000 T. less than for 1920, and 35,000,000 T. less than for 1919 during the same period. While less coal has been used, owing to slowing down of industries, even a moderate increase in manufacturing activity would result in wiping out the coal now in storage yards, and would result in a shortage the coming winter.

There seems no likelihood of any material reduction in price, while a shortage would cause a sharp advance. A power plant is dead without coal. Each plant executive must use his best judgment as to his wisest course, but a shut-down for lack of fuel due to lack of foresight is hard to explain or excuse. Errors of judgment are human and may be forgiven. Failure to consider future needs and plan accordingly is inexcusable. "A word to the wise is sufficient."

Power Plant Slogans

Keep and Analyze Operating Records in Every Power Plant.
Develop Water Power Sites.
Promote Health and Safety in Power Plants.
Handle Coal and Ashes Mechanically.
Employ Engineers for Engineering Work.

Life as a Business Proposition*

By Dr. Frank Crane

LIFE has been called all sorts of things. Life is a dream, a gambling game, an opportunity from which to get all the fun and the least pain possible, a probation preparatory to the next life, a vale of tears, and so on.

Suppose we consider life as a business proposition. Look at it from a practical, profit-and-loss, shrewd and common sense viewpoint.

Very well. First, what can we get out of it? Only wages. There are no endowed and privileged ones, all are day laborers; for everyone, when the work's over, must leave all he has gained and go back to that nothingness from which he came, as stark naked and poor as when he arrived. All the billionaire gets out of life is exactly what the bricklayer gets, his board and clothes and amusements.

What is the wage of Life? Life's pay is happiness. On Life's book happiness is credit and unhappiness debit.

It's happiness we all strive for, of one kind or another, whether beer and cakes or turtled feasts, overalls or dress-suits, pinochle on a cracker-box or stock gambling on the market, social distinction, wealth display, political success, intellectual achievement—it's all happiness, according to taste.

How is happiness to be secured, how can one be sure to get his pay? By finding out what he really wants. This is not so easy. Most people work a lot for what they think other people think they want.

How can one find that out? By experiment, trying out various activities until he finds the one in which he can most enthusiastically express himself.

How should one get his pay? Every day. Not at the end of the task. Unless every day brings its satisfaction, you are cheating yourself.

How can one tell what sort of things pay and what sort do not pay? By the collective experience of mankind, and by accepting the guidance of reliable teachers.

What does the cumulative experience of mankind show? That only those acts which are fundamentally just, fair, honest and kind are those that invariably pay.

What we call goodness more than pays every day, it leaves something over, a deposit in the happiness bank, which becomes a reserve fund from which we draw dividends. The good are the happiness capitalists. The bad are the happiness spendthrifts.

* Copyright, 1921, by Dr. Frank Crane.

A New Type Underfeed Stoker

WITHIN the past few years, boilers have been driven to capacities hardly dreamed of 10 yr. ago, and much higher over-all efficiencies have been secured. The cost of power production has been materially lowered, due to the lessened number of boilers required, and to economies effected in fuel saving, labor and maintenance.

This difference has been largely due to the development of the underfeed stoker, with its range of capacity, its complete mixing of air and fuel, and its provision for the removal of ash at regular intervals.

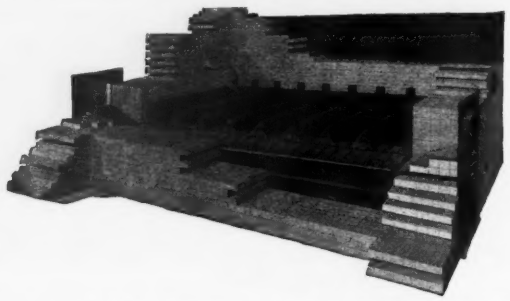


FIG. 1. REAR VIEW MULTIPLE RETORT DETROIT UNDERFEED STOKER

The underfeed stoker is adapted to all grades of bituminous coal; is essentially a forced draft stoker, since it operates with restricted air openings, and deep fires; and its forcing capacity is almost unlimited, instances being known where this stoker has been driven to over 400 per cent rating.

The Detroit Stoker Co., Detroit, Michigan, has designed a new underfeed stoker, made in two designs. One is the single-retort, side-cleaning stoker, for boilers

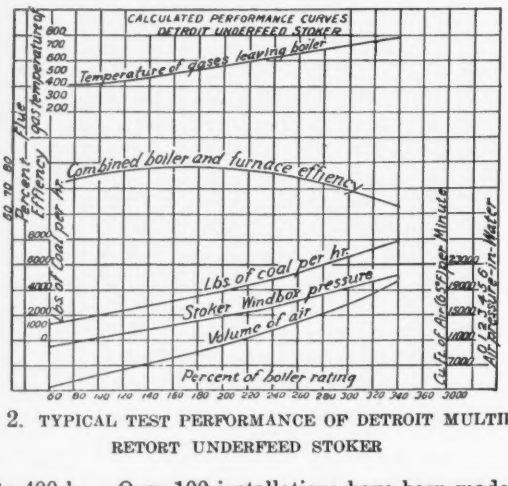


FIG. 2. TYPICAL TEST PERFORMANCE OF DETROIT MULTIPLE RETORT UNDERFEED STOKER

up to 400 hp. Over 100 installations have been made of this stoker and all are operating successfully. The larger stoker is of the multiple-retort, end-cleaning type for large installations, and is designed on principles which have been successfully worked out in the smaller machine. It has been thoroughly tried out for 2 yr. under all conditions of operation.

The striking feature of these stokers is a level fuel bed, Fig. 1. Retorts and tuyeres are placed horizontally, and the thickness of the fuel bed, together with its rate of movement to the rear, are at all times directly under control of the operator. The entire movement of the fuel is mechanical, thus assuring uniform progressive combustion, which is completed by the time the fuel traverses the length of the bed, so that only refuse in the proper condition is delivered to the dump plates.

The principles of design may be briefly tabulated as follows:

For the construction, mechanically driven, adjustable rams; horizontal, multiple retorts and tuyeres; auxiliary pushers with independent adjustment; hand operated end dump.

For the air regulation, front or side control; adjustable air intake under stoker; admission to fuel bed through hundreds of openings in tuyeres; adjustable admission over fuel bed through ports in front wall; low pressure for high capacity.

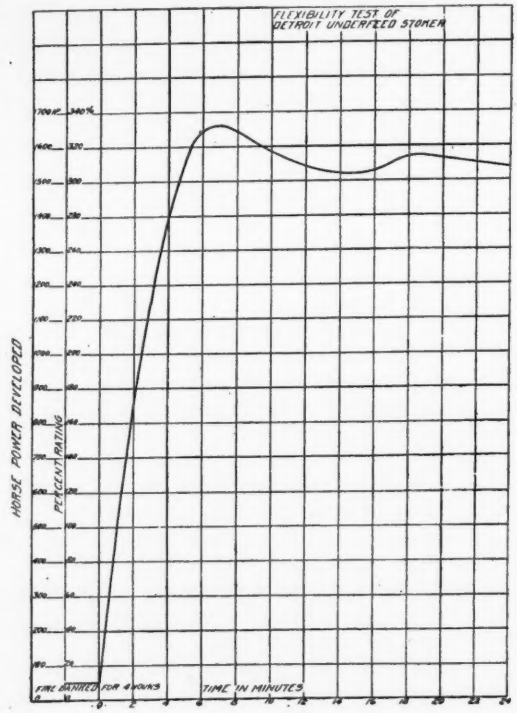


FIG. 3. FLEXIBILITY TEST DETROIT UNDERFEED STOKER.

The rams are mechanically driven, the construction permitting the use of either motor or engine drive, requiring low power for operation. The adjustable stroke of the ram gives the operator complete control of the thickness and shape of the fuel bed at all times.

Specially designed retorts and tuyeres insure efficient combustion with low air pressures, which means a considerable saving in initial investment in fans and engines and reduces operating and maintenance expenses.

Clinker formation on the side or bridge walls is practically eliminated with the Detroit underfeed stoker, as the side wall tuyeres, designed for admitting air at certain locations of the fuel bed according to local conditions, extend far above the retorts and protect the brickwork.

Air admitted through the tuyeres is forced through the fuel bed at right angles to the retorts, consequently the major portion of light ash and soot is kept in the

stoker furnace chamber and not deposited in the front bank of boiler tubes.

The ash dump has been arranged for hand operating because of low cost and elimination of power required for operation and maintenance charges. Dump plates, which are balanced, are of extra heavy construction, well reinforced, and designed for hard service. The plates are lowered and raised by means of a worm and segment, with gear ratio approximately 35 to 1, so that operation is readily effected with small effort.

For wide boilers, where stokers containing six retorts or more are employed, the dump plates may be arranged for handling in sections.

Supply of coal to the furnace and the air pressure, are automatically regulated by the steam pressure of the boiler, so that, if the steam pressure drops, more fuel and air are supplied, and conversely, when the steam pressure rises above a predetermined point, the quantities of fuel and air being supplied are decreased. This regulation is adapted equally to installations using motor or steam engine drive. The automatic control device is so sensitive that it assures an even steam pressure, regardless of fluctuations in load on the boiler. The fires may be banked and held by the simple process of rapidly feeding in a quantity of coal and then shutting off both air and coal supply.

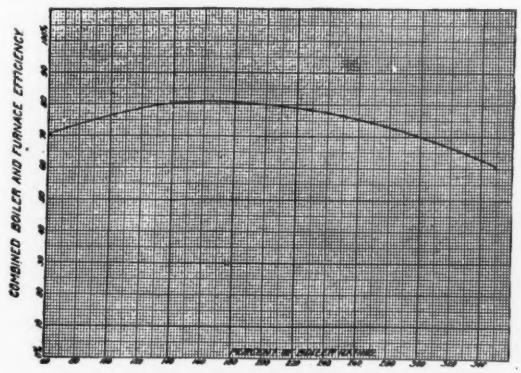


FIG. 4. CALCULATED PERFORMANCE CURVES

Figure 2 shows a typical test performance of the new Detroit underfeed stoker at capacities ranging from 60 to 350 per cent of normal boiler rating. It will be seen that the combined boiler and furnace efficiency drops a little as the load increases, which indicates a high degree of economy under normal load conditions and a high and economical reserve capacity to meet unusual loads.

Extreme flexibility of the new stoker is indicated by Fig. 3, taken from an actual test, made on a 600-hp. water-tube boiler. The fire had previously been banked for 4 hr., with the boiler developing only about 10 per cent of its normal rating. It will be seen that 1 min. after the heavy load was placed on the boiler it was developing normal rating; within 2 min. it was developing 200 per cent rating, and within 4 min. a rating of 300 per cent, which was held without difficulty. Ability to meet peak loads quickly is of the greatest importance, for central stations, and is of almost equal importance in large industrial plants, where quantities of steam are irregularly required for manufacturing processes. In particular when the number of boilers in a plant is limited, extreme flexibility on the part of the stoker installation is an invaluable asset.

Comparison of the calculated performance curves, Fig. 4, of the new stoker, with the actual test curves, Fig. 2, shows that results achieved in practice exceed those theoretically determined, which ability to meet performance guarantees readily is extremely desirable.

The single retort, side cleaning stoker (Figs. 5 and

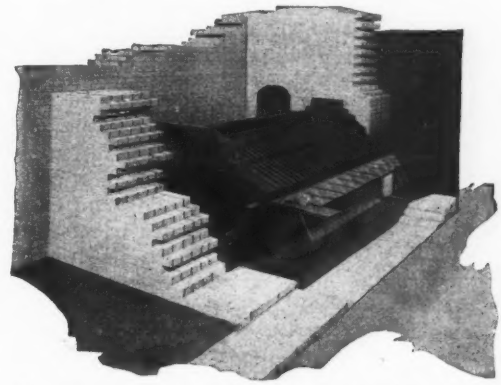


FIG. 5. REAR VIEW SINGLE RETORT DETROIT UNDERFEED STOKER

6), is designed on the same principle as the multiple retort stoker just described. It differs in design from the latter, however, in the location of the dump, which is placed on the side, is hand operated and can have refuse either removed through ash doors in the front, or delivered to a hopper or ash conveyor below.

Arrangement for admitting air, under control through specially designed tuyeres at both sides of the retort, gives a high overload capacity on quick demand. Regu-

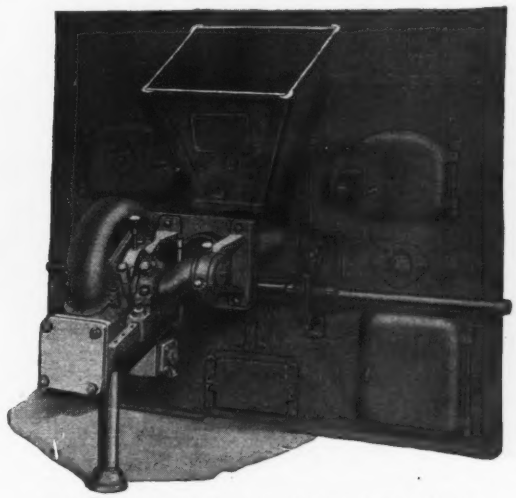


FIG. 6. FRONT VIEW SINGLE RETORT STOKER

lation of feed of the coal and removal of the clinker and ash are both accomplished without interference with the operation of the stoker.

This smaller stoker has a mechanically driven plunger or ram operated by reduction gears from a shaft below, driven by a small engine or motor. All gears, worms and moving parts are fully enclosed, running in oil and easily accessible; simplicity of design with no moving parts in the fire, insures a low main-

tenance cost. Control of the air in the wind box and the convenient arrangement for regulating the amount of coal to be burned in accordance with the load required, produce a uniform steam pressure in the boiler.

News Notes

ANNOUNCEMENT is made by the American Steel & Wire Co. of the appointment of H. S. Durant, sales agent, and M. W. Floto, assistant sales agent, at the Detroit office, to succeed M. Whaling and T. J. Usher, Jr., who have resigned.

IN CONNECTION with its plans for the reclamation of its semi-arid states, the Brazilian federal government has retained Dwight P. Robinson & Co., of New York, to supervise a large amount of engineering and construction work. This work, which is located in the states of Ceara and Parahyba, will include the construction of five large dams to create storage reservoirs, some of which are to be larger than any artificial reservoirs existing elsewhere. The work is to be conducted under the direction of the Brazilian government, and in its ultimate importance and economic value it is comparable to the irrigation work carried on since 1903 by the United States government.

WITH the erection and completion of a large valve machine shop, and other improvements, the Fulton Co., of Knoxville, Tenn., has the distinction of having the largest plant in the world devoted to the manufacture of thermostatic instruments. In all its products, the seamless metal bellows, known as the Sylphon, is the essential element. The plant itself is modern built of reinforced concrete, three stories high, and has a floor space of over 250,000 sq. ft. The company operates its own brass foundry and iron foundry, also complete pattern shop, tool room, machine shop, forging plant and box factory are incorporated within the plant. Hydroelectric power is used for operating the machines, and each department is supplied with separate meters for gas, water and electricity.

Books and Catalogs

CENTRAL STATION RATES IN THEORY AND PRACTICE, by H. E. Eisenmenger; first edition, 382 pages, illustrated, 4¾ by 7 in., flexible cloth; Chicago, 1921.

This book without doubt fully justifies the author's effort to cover a difficult and intricate subject in a clear and comprehensive manner. It has been his intention to produce a book which should be useful to every student of electric rates, to the beginner as well as the expert. In consequence of this, some parts of the text will be found too elementary for the advanced student, whereas other portions will be of interest to those only who wish to penetrate more deeply into the subject.

To make the book smooth reading matter for the beginner as well as the advanced student, both the very elementary and the advanced portions of the work have been detached from the main text and segregated in appendices. The advanced portions are of such a nature that the use of higher mathematics is indispensable for the solution of many of the problems arising and the employment of appendices permits the nonmathematical reader to skip such portions without losing the context.

The mathematical deductions have been made as plain and as easily intelligible as possible. The results of many of the mathematical deductions are presented in such form that they can be applied by anybody with a knowledge of ordinary algebra or arithmetic.

The book is divided into six sections and 16 appendices. Beginning with section one, the sections cover the following points: The Cost of Electric Service; The Price of Electric Service; Systems of Charging; Rate Analysis; Accuracy of Rates; Public Utilities and Public Regulation.

The first three appendices are written for the nontechnical reader and are devoted to the explanation of simple electrical terms. A partial list of subjects to which other appendices are devoted are as follows: The influence of the Central Station's Capacity on the operating expense; Approximations made to compute the demand cost of the plant; Apportionment of the demand cost to the individual consumers; Relation between selling price and earnings; Reasons for the desirability of a gradation of the energy charges with pure meter rates; Theoretical remarks about the step rate; Graphical representation and analysis of the block meter rate; etc.

These appendices are not merely unrelated supplements, but are an essential part of the book segregated to enable each reader to pick out those portions suited to him. The book is well indexed, which renders it suitable for reference as well as study.

THE APPLICATION of the Curtis steam turbine for driving circulating and boiler feed pumps, as well as centrifugal pumps for all purposes, fans and blowers and other apparatus has been successfully developed by the General Electric Co.

The turbine may be designed for either condensing or non-condensing operation. It may be adapted for any steam pressure from 60 to 250 lb., for either dry or superheated steam, and for speeds from 1300 to 5000 r.p.m. It may be arranged with either one, two or three stages, depending upon the operating conditions.

According to Bulletin No. 42,019, issued by the company, this turbine represents the best type of design and construction, based on practical experience gained in building Curtis steam turbines. Every detail has been worked out so as to make all parts as simple as possible and of ample size and strength.

A description of the principle involved in this turbine, and a careful summary of its several parts, including wheel, shaft and buckets, wheel, casing, bearings, packing, governor, governor valve, emergency governor and other elements, is included.

SMALL TOOLS CATALOG No. 46, including description and price lists of taps and dies, screw plates, milling cutters, pipe tools, drills and reamers, has been received from Greenfield Tap and Die Corporation, Greenfield, Mass.

APPLICATION of Oil Circuit Breakers is the title of a new publication issued by the Westinghouse Electric & Mfg. Co., known as Special Publication 1643. This includes a complete discussion of the application of circuit breakers, together with an outline of the characteristics of several types of oil circuit breakers.